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MISSOURI PUBLIC SERVICE COMMISSION

CASE NO. EA-2015-0146

DIRECT TESTIMONY

OF

TODD SCHATZKI, Ph.D.

ON

BEHALF OF

AMEREN TRANSMISSION COMPANY OF ILLINOIS

Boston, Massachusetts
May 2015

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I. INTRODUCTION AND WITNESS QUALIFICATIONS

Q. Please state your name, business address and present position.

A. My name is Todd Schatzki. I am employed by Analysis Group, Inc. ("Analysis Group"), where I am a Vice President in the Boston office. Analysis Group is a firm that provides microeconomic, strategy and financial analyses. My business address is 111 Huntington Avenue, 10th Floor, Boston MA 02199. Analysis Group has more than 600 employees and offices in Beijing, Boston, Chicago, Dallas, Denver, Los Angeles, Menlo Park, Montreal, New York City, San Francisco and Washington, D.C.

Q. Please summarize your professional experience and educational background.

A. I received a Bachelor of Arts in physics from Wesleyan University, a Master's in City Planning, Environmental Policy and Planning from the Massachusetts Institute of Technology and a Ph.D. in Public Policy from Harvard University. Since receiving my doctorate degree, I have worked with several economic consulting firms, including National Economic Research Associates, Inc., LECG, LLC and now Analysis Group. My professional experience and qualifications are summarized in my curriculum vitae, which is included as **Schedule TS-01.**

For nearly fifteen years, I have worked on energy sector economics, regulation, and policy, including work for government agencies, regulators, market operators, non-profit organizations, and private corporations. This work has included: market design; economic and financial analysis of energy and environmental regulations and infrastructure changes; ratemaking design and analysis; design and assessment of environmental regulations affecting the electric power sector; and assessment of market competition and manipulation. My work has appeared in both academic and industry journals such as the *Journal of Environmental Economics and Management*, *The Electricity Journal*, and *Public Utilities Fortnightly*, and in publications associated with institutions such as the AEI-Brooking Joint Center for Regulatory Studies and the Harvard Regulatory Policy Program.

In recent years, much of my work has involved wholesale power markets in a number of regions of the U.S. I have helped in the review and redesign of market rules, performed economic analysis of the impacts of proposed market rules, evaluated resource performance under existing market designs and assessed economic damages associated with disputes regarding wholesale power contracts. I have worked for market operators in New England ("ISO-New England") and New York ("NYISO") on a variety of issues related to market design, market monitoring and the analysis of the impact of market rule changes under consideration. My work has involved issues in many organized wholesale markets, including California ISO, ISO-New England, Midcontinent Independent System Operator, Inc. ("MISO"), PJM Interconnection and NYISO. I have utilized production cost models on numerous occasions to evaluate the impacts of new regulations and changes in generation and transmission infrastructure. This work has included multiple confidential assignments and analysis of transmission projects in the MISO footprint. I have submitted testimony to both federal and state regulatory commissions.

Q. On whose behalf are you testifying in the current proceeding?

A. I am testifying on behalf of Ameren Transmission Company of Illinois ("ATXI"), a wholly-owned subsidiary of Ameren Corporation, in support of its request for a Certificate of Public Convenience and Necessity ("CCN") for a transmission line project in northeast Missouri.

Q. Are you familiar with the project proposed by ATXI?

A. Yes. ATXI is seeking a CCN authorizing it to construct, operate and maintain a 345-kV electric transmission line, approximately 95 miles in length, and related facilities.[1] The to-be-constructed facilities are referred to as the Mark Twain Project by ATXI, and I refer to these facilities as the "Project." These facilities are also designated by MISO as Multi Value Projects, and were approved by MISO's Board of Directors in December 2011.

II. PURPOSE, SCOPE AND SUMMARY OF CONCLUSIONS

Q. What is the purpose of your testimony?

A. I understand that the Missouri Public Service Commission ("Commission") has generally evaluated an application for a CCN under the five so-called *Tartan* factors,[2] which include:

- Whether there is a need for the facilities and service;
- Whether the applicant is qualified to own, operate, control and manage the facilities and provide the service;
- Whether the applicant has the financial ability for the undertaking;
- Whether the proposal is economically feasible; and
- Whether the facilities and service promote the public interest.

[1] The Project also includes approximately 2.2 miles of 161-kV transmission line near Kirksville, Missouri.
[2] These factors were outlined in *In Re Tartan Energy*, GA-94-127, 3 Mo. P.S.C.3d 173, 177 (1994).

My testimony provides economic analysis that addresses whether the Project meets the criteria related to whether there is a need for the facilities and services, whether it is economically feasible and whether it is in the public interest.

Q. Are you sponsoring any schedules in support of your direct testimony?

A. Yes. In addition to this direct testimony, I am sponsoring **Schedule TS-01** (curriculum vitae), **Schedule TS-02** (Technical Appendix), and **Schedule TS-03** (Tables of Results).

Q. Please summarize your conclusions.

A. I find that the Project would provide the state of Missouri with many positive economic benefits that demonstrate that the Project is in the public interest. In addition, as I show, the Project would enable additional wind generation to support achievement of Missouri renewable requirements, thus demonstrating need for the Project, and the Project was developed under a MISO planning process that appropriately balanced economic tradeoffs, thus indicating that the Project is economically feasible.

My analysis finds that the Project's development would be expected to decrease wholesale prices for electric power and decrease the costs of producing electricity to meet customer loads. Reductions in production costs, in turn, would lead to reductions in the charges for electric power to retail customers in Missouri that far outweigh the impact of transmission charges to Missouri load-serving entities (primarily Ameren Missouri) that would arise from the Project. As a result, these reductions in payments for electric energy would far outweigh the ultimate impact of the Project on Missouri customers' retail electric rates. In addition, my analysis reflects supplies of wind power that would be enabled by the Project and that can support the achievement of state renewable energy targets. Finally, I find that the Project would reduce emissions of carbon dioxide ("CO_2") generated throughout the MISO footprint, as well as reduce emissions of nitrogen oxides ("NO_X"), sulfur dioxide ("SO_2") and mercury from sources within Missouri. In total, these impacts would provide substantial benefits to Missouri, as well as to the MISO region as a whole.

Q. How is your testimony organized?

A. In Section III of my testimony, I provide a description of the proposed facilities. In Section IV, I describe the approach used to evaluate the Project's economic impact. Finally, in Section V, I report the results of my analysis.

III. DESCRIPTION OF THE PROPOSED TRANSMISSION FACILITIES

Q. What is your understanding of the proposed facilities?

A. The Project is described more completely in the direct testimony of ATXI witness Dennis D. Kramer, as well as in the direct testimony of ATXI witness James Jontry. I understand that the Project includes transmission facilities that will be routed south from the Missouri-Iowa border to the proposed ATXI Zachary Substation near Kirksville, Missouri, and then easterly on to the Maywood switching station. I also understand that the Project would include 95 miles of new 345-kV transmission line, a new 345-kV terminal and 345/161-kV step-down transformer at the new Zachary Substation, and a 161-kV connector line running from the Zachary Substation to Ameren Missouri's existing Adair Substation.

Q. What is your understanding of the total cost of the proposed facilities?

A. As indicated in the testimony by ATXI witness Mr. Jontry, the Project is expected to go into service in November 2018 with an expected nominal cost of $224 million. These costs would be incurred over the period 2014 until 2018.

Q. What is your understanding of the principal benefits to the regional electric system that will be provided by the Project?

A. The Project would provide a wide range of benefits, including mitigation of potential reliability concerns, reduced congestion and improved integration of distant generation resources within the MISO footprint. Many of these benefits are described in the testimony of ATXI witness Mr. Kramer. These benefits were also identified in the MISO planning process that developed the Project as an element of the Multi Value Project portfolio.

Q. What is the Multi Value Project ("MVP") portfolio?

A. The MVP portfolio is a package of transmission projects that allows for a more efficient dispatch of generation resources, opening markets to further competition and spreading the benefits of low-cost generation. Through a MISO planning process, MVPs have been "determined to enable the reliable and economic delivery of energy in support of documented energy policy mandates or laws that address, through the development of a robust transmission system, multiple reliability and/or economic issues affecting multiple transmission zones."[3] The Federal Energy Regulatory Commission approved the MVP methodology because it "is an

[3] Midwest Independent Transmission System Operator, Inc. ("MISO"), 133 FERC ¶ 61,221 at Para 1 ("Dec. 16, 2010 Order"). See also the listing of the three MVP criteria in Section II.C.2 of Attachment FF of the MISO Tariff, as follows:

> Criterion 1. A Multi Value Project must be developed through the transmission expansion planning process for the purpose of enabling the Transmission System to reliably and economically deliver energy in support of documented energy policy mandates or laws that have been enacted or adopted through state or federal legislation or regulatory requirement that directly or indirectly govern the minimum or maximum amount of energy that can be generated by specific types of generation. The MVP must be shown to enable the transmission system to deliver such energy in a manner that is more reliable and/or more economic than it otherwise would be without the transmission upgrade.
> Criterion 2. A Multi Value Project must provide multiple types of economic value across multiple pricing zones with a Total MVP Benefit-to-Cost ratio of 1.0 or higher ....
> Criterion 3. A Multi Value Project must address at least one Transmission Issue associated with a projected violation of a NERC or Regional Entity standard and at least one economic-based Transmission Issue that provides economic value across multiple pricing zones. The project must generate total financially quantifiable benefits, including quantifiable reliability benefits, in excess of the total project costs ....

important step in facilitating investment in new transmission facilities to integrate large amounts of location-constrained resources, including renewable generation resources, to further support documented energy policy mandates or laws, reduce congestion, and accommodate new or growing loads."[4] MISO performed a comprehensive assessment of the portfolio of 17 MVPs, which included a recommendation that each of the 17 projects be approved by MISO's Board of Directors for inclusion in Appendix A of the MISO Transmission Expansion Plan process and implemented.[5] On December 8, 2011, the MISO Board of Directors approved this recommendation. The costs of MVPs are reflected in transmission charges assessed by MISO under its tariff that are charged to all load-serving entities within MISO and to those exporting power from MISO via a per mega-watt hour ("MWh") charge.[6]

Q. Is the Project a Multi Value Project?

A. Yes. The Project is an integral part of a MVP portfolio, which includes transmission projects throughout the MISO footprint. The Project comprises nearly all of MVP 8 and the Missouri portion of MVP 7. MVP 7 also includes facilities that extend from the Missouri-Iowa border into Iowa's Ottumwa substation that are not an element of the Project, but are to be developed by the MidAmerican Energy Company. My analysis of the Project considers the impact of both MVP 7 and 8, in their entirety. This assumption is reasonable because the transmission line from West Adair, Missouri to Ottumwa, Iowa, as currently designed, does not interconnect with any other transmission facilities between these two points. Consequently, there would be no reason to construct the Iowa portion of MVP 7, without the Missouri portion

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[4] Dec. 16, 2010 Order at Para 3.
[5] MISO, "Multi Value Project Portfolio, Results and Analyses," January 10, 2012 ("MVP Report").
[6] *See* MISO Tariff, Schedule 26A, Multi Value Project Usage Rate, and Attachment MM, Multi Value Project Charge. Note that exports to the PJM Interconnection system are not assessed MVP charges.

of MVP 7, because the line would not connect to any nodes in the transmission system and thus could not flow power.

Q. Did the selection of the MVP portfolio reflect economic criteria?

A. Yes. The MVP portfolio was developed after a lengthy planning process designed to, among other things, support the achievement of state renewable energy requirements through infrastructure investments that minimized costs while meeting other state policy objectives.[7] Initial stages of this process evaluated the costs of alternative wind zone configurations in light of tradeoffs between achieving renewable requirements through "regional" wind resources, which include the most productive (highest capacity factor) wind resources but require greater transmission infrastructure to enable delivery, and "local" wind resources, which often are less productive but require less new transmission. Through this process, MISO identified the scenarios with the lowest overall cost, which were scenarios that combined local and regional resources. The MVP portfolio was designed to ensure delivery of these wind resources sufficient to meet state renewable requirements, while minimizing costs. Thus, the Project was developed as an element of a cost-effective approach to achieving state renewable targets, while providing other economic and reliability benefits, thus indicating that the Project is "economically feasible."

IV. DESCRIPTION OF ANALYTICAL APPROACH

Q. What measures of economic outcomes do you evaluate in your analysis?

A. In my analysis, I develop quantitative estimates of the Project's impact on prices, production costs and emissions. As I describe below, these measures provide estimates of the

[7] See MISO, "RGOS, Regional Generation Outlet Study," November 19, 2010, particularly Sections 4 and 5.

Project's impacts on overall social costs, consumer expenditures and environmental impacts, each of which have important implications for whether the Project is in the "public interest" and is economically feasible, which are two of the five *Tartan* criteria.

Q. Why did you evaluate these particular economic outcomes measures?

A. Each of the measures of economic outcomes provides information about the economic impacts associated with the Project that are valuable when assessing whether the Project is in the public interest. Reductions in prices can be consistent with improved market outcomes, including reductions in the costs of production (on the margin) and increases in wholesale market competition. Reductions in production costs indicate improved economic efficiency in meeting electric energy loads, lower social costs, and reduced payments by customers in Missouri for electric energy service. Reductions in emissions lower the social cost of supplying electric energy. As I discuss, the reductions in prices, production costs and emissions that I find in my analysis indicate improved economic outcomes, which support the conclusion that the Project is in the public interest.

Q. Please provide a brief summary of your analytical approach.

A. Changes in prices, production costs and emissions are estimated in two steps. In the first step, a market model is used to estimate the market outcomes of interest – prices, production costs and emission costs – under different assumptions about the transmission infrastructure elements that are in service. A "study case" assumes the Project is in service, while the "base case" assumes the Project is not in service. The second step calculates the difference between outcomes in the "base case" and "study case" – this change in market outcome captures the market impact from developing the new infrastructure. In this section of my testimony, I describe the approach used to evaluate prices, production costs and emissions, with further detail provided in **Schedule TS-02**.

Q. Please describe generally the analysis that you conducted.

A. The analysis uses the PROMOD IV ("PROMOD") market simulation model to estimate market outcomes in Missouri with and without the Project. PROMOD, which is marketed by Ventyx, simulates the operation of the regional generation and transmission system, in so doing reflecting a variety of generator operating characteristics and constraints and transmission system topology and limits.

The PROMOD market simulation model and the data set employed in my analysis are identical to those used by MISO in the above-noted MISO MVP Report assessing the 17 projects in the MVP portfolio.[8] These data include information on customer loads, transmission infrastructure, forecasted fuel prices, and existing and new generation resources. Similarly, the scenarios I analyzed, which I discuss further below, are the same as those analyzed by MISO. **Schedule TS-02** attached to this testimony further describes the PROMOD analysis and the data set that was used.

The PROMOD analyses were run for two future study years, 2021 and 2026, using four different scenarios for each year.[9] These scenarios, which are described further below and which were also used in the MISO MVP Report, contain different assumptions about load growth, natural gas prices, carbon constraints and other policy matters, and therefore allow an assessment of the relative robustness of the study results across a range of possible futures.

[8] In this regard, MISO's MVP Report analysis compares the results between the "with 17 MVP" case and a "but for" case that does not include any of the 17 MVPs, whereas the analyses reported on herein compare the results between the "with Project" case including all 17 MVPs and a "without Project" case that includes only the other 16 MVPs.
[9] 2021 and 2026 are the same years utilized by MISO in its MVP Report, and reflect typical future year periods used by MISO in its MISO Transmission Expansion Plan process.

Q. What geographic region is covered by the PROMOD analysis?

A. The geographic region covered by the PROMOD analysis includes a large portion of the Eastern Interconnection,[10] including all of MISO, adjacent operating systems (including the Southwest Power Pool ("SPP") and the PJM Interconnection), and other indirectly interconnected systems.

Q. Please describe generally the analysis of prices.

A. Within organized wholesale markets, such as MISO and SPP, electricity prices are developed for individual "nodes" on the transmission system. PROMOD estimates these "nodal" market prices, which commonly are referred to as locational marginal prices or LMPs.[11] The hour-by-hour LMP values produced by the PROMOD analysis were used, along with the amount of load served from each of the pricing nodes, to develop load-weighted average wholesale energy prices. This load-weighted average wholesale energy price, which I refer to as the Missouri LMP, reflects all nodes in the state, including those in MISO, SPP, and other systems within Missouri. The difference between the Missouri LMP without the Project and the Missouri LMP with the Project represents the wholesale energy price effect from implementing the Project. If this difference is negative, as turns out to be the case, then this is an indication that the Project will lower average wholesale electric energy prices.

Q. Please describe generally the analysis of production costs.

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[10] The Eastern Interconnection includes roughly the eastern two-thirds of the "lower 48" (with the exception of portions of Texas), plus Canadian provinces to the east of Alberta.

[11] Differences in LMPs from location to location occur because of differences in marginal losses, as well as the presence of congestion. When congestion is present, it is not possible to fully exploit differences in marginal generating costs at different locations and LMPs in transmission-constrained areas will rise above LMPs outside those transmission-constrained areas.

A. My testimony provides estimates of the change in production costs to supply Missouri load associated with the Project. I refer to these as Missouri Production Costs. These costs reflect the fuel, variable operations and maintenance, emission allowance, and start-up costs associated with supplying Missouri load, adjusted for net sales and purchases of power with areas outside of Missouri, including areas within and outside of MISO. Missouri Production Costs reflect the costs to supply all Missouri loads, including those located in MISO, SPP and other systems. I also estimate the change in production costs for the entire MISO region, which reflects the fuel, variable operations and maintenance, emission allowance, and start-up costs associated with supplying all MISO load, adjusted for net sales and purchases of power with areas outside of MISO. I refer to these as MISO Production Costs.

Q. Do production costs reflect social costs?

A. Yes. Generally speaking, social costs reflect the cost to society of economic activity or decisions. Social costs include the opportunity cost of using resources, including the various electricity production costs described above, such as the use of fuel to produce electricity or the use of labor to operate power plants. Thus, the costs captured by the estimated production costs are all social costs. Social costs also include welfare losses associated with economic decisions, including environmental impacts associated with the production of electricity. As I discuss below, to capture these types of impacts, I separately calculate the change in emissions from development of the Project.

Q. Do production cost estimates also provide a reliable means of assessing changes in retail payments by Missouri customers?

A. Yes. Missouri customers are served by load serving entities ("LSE") that charge prices that are based on the LSE's cost of service. These LSEs include investor-owned utilities regulated by the Commission, and electric cooperatives and municipal power companies that establish prices independent of state regulation. When customers are served by companies with rates that are set based on the cost-of-service, the prices charged to customers will generally reflect costs of producing power, rather than wholesale market prices. As a result, a reduction in production cost will generally flow through to customers in the form of lower rates. Because Missouri customers are served by companies that charge rates that are set based on the cost-of-service, changes in production costs provide an appropriate means of estimating potential changes in retail payments for electric energy by Missouri customers.

Q. Do these production cost estimates account for net sales and purchases made by LSEs in Missouri?

A. Yes, they do. To serve their customer's loads, LSEs in Missouri can own generation facilities, with the costs of owning and operating these facilities, including production costs, being recovered through the rates charged to their customers. These generation facilities may produce less than, greater than or exactly the amount consumed by the loads of LSE customers. When there is excess supply, these LSEs realize positive net revenues from sales to the wholesale market, with some portion (and potentially all) of revenues in excess of costs returned to customers. Likewise, when LSEs rely on market purchases to meet some portion of its customer loads, the cost of these purchases, which would reflect wholesale market prices and not production costs, are included in customer rates. Because these net sales and purchases (relative to load) affect the LSE's cost to serve load, an adjustment to account for them is appropriate. Consider the impact of a project that reduces both LMPs and production costs for a LSE that generates more power than its load consumes. For this LSE's customers, the sale of excess energy provides a benefit by offsetting a portion of the production costs of meeting their load. If the project reduced LMPs, this would reduce the net revenues earned from these sales, which could make customers worse off if this reduction in net sales revenue was larger than any production cost savings created by the project. By adjusting production cost estimates to account for net sales and purchases (at appropriate wholesale market prices), my approach accounts for such a possibility, although, as it turns out, adjusted production costs decline with the Project in service in all scenarios evaluated, even after accounting for any potential reductions in the revenues from power sales.

Q. Do the estimated LMPs and production costs reflect ancillary services requirements?

A. Ancillary services are services provided by resources to ensure reliable, secure and efficient operation of the power system. In MISO, these services include operating reserves (spinning and supplemental) and regulation. The PROMOD analysis incorporates MISO's operating reserve requirements, but does not account for regulation requirements. However, the costs of meeting these requirements reflect a small share of overall production costs.[12]

Q. Does the PROMOD analysis reflect the complete set of wholesale electricity market benefits from the Project?

A. No. The PROMOD analysis quantifies the lower wholesale electric energy prices and production costs that will result from the Project, but it does not quantify other potential wholesale electricity market benefits such as lower operating reserve and capacity requirements, which in turn would lead to lower costs of fulfilling these requirements. Reductions in operating reserve and capacity requirements could arise if the Project reduces congestion that can limit the

[12] For example, in 2013, revenues for supply of regulation services were about $20 million, while total revenues through the MISO markets, including energy, capacity and uplift, were over $15 billion. MISO, "MISO 2013 Annual Market Assessment Report," Information Delivery and Market Analysis, June 2014.

flow of capacity and reserves across the MISO footprint. By reducing these limitations, fewer capacity and reserve resources might be needed to maintain a reliable transmission system, thus lowering costs. Focusing just on the change in wholesale electric energy price and production costs from the PROMOD analysis therefore will understate the full range of market benefits that can be expected from the Project.

Q. Please describe generally the analysis of air emissions.

A. The production of electric energy results in environmental impacts, including air emissions. The PROMOD analysis estimates emissions of CO_2, NO_X, SO_2 and mercury. For CO_2 emissions, changes in emissions are measured across the entire MISO footprint. I refer to these as MISO CO_2 Emissions. It is appropriate to evaluate changes in CO_2 emissions over the entire MISO footprint because CO_2 emissions have the same impact regardless of where they are emitted. In contrast, NO_X, SO_2 and mercury emissions are measured only from generation facilities within Missouri. I refer to these as Missouri NO_X emissions, Missouri SO_2 emissions, and Missouri Mercury Emissions. For these emissions, it is appropriate to analyze impacts based on emissions from in-state sources because their impact depends on the proximity of the receptor to the original source.

My analysis estimates the change in emissions from the development of the Project. If emissions are lower with the Project, which happens to be the outcome, this indicates the environmental impacts, and thus social costs, are lower with the Project in service. For certain emissions, including SO_2 and CO_2 in certain scenarios,[13] estimated production costs include the cost of allowances required for regulatory compliance. I provide actual emission levels, as well

[13] CO_2 allowance costs are assumed in the Combined Energy Policy and Carbon Constrained scenarios.

as accounting for these allowance costs, because the cost of allowances included in production costs may differ (higher or lower) from the social cost of the these emissions.[14]

Q. Does the PROMOD analysis reflect other benefits from the Project, such as reliability improvements?

A. No. The PROMOD analysis only considers changes in energy market outcomes, and does not evaluate improvements in reliability from the Project. These benefits are described in the testimony of Mr. Kramer.

Q. Does your analysis assume the Project would support the development of additional wind resources?

A. Yes. Absent the Project, the quantity of wind resources that could be reliably supported would be diminished. As a result, the Project supports the achievement of Missouri's renewable energy requirements, thus demonstrating the need for the Project.

Aside from the Project's new transmission facilities, the only difference between the "with Project" case and "without Project" case is the quantity of wind power assumed in each case. The quantity of new wind power resources is reduced in the "without Project" case based on MISO's determination that less wind generation capacity can be reliably supported. My analysis reduces wind supply from specific resources that would be enabled by the Project, reflecting a total of 1,577 to 2,011 MW of wind capacity, based on analysis performed by MISO. These data assumptions are described in further detail in **Schedule TS-02.**

Q. What specific scenarios are included in your analysis?

A. The following four scenarios were included:

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[14] My analysis does not account for any reductions in allowance prices that could arise due to reduced demand for allowances.

i) Business as Usual, Low Demand - assumes the continuation of current energy policies and continuing "recession-level" demand and energy growth;

ii) Business as Usual, High Demand - assumes the continuation of current energy policies and a return to pre-recession demand and energy growth levels;

iii) Carbon Constrained - assumes the continuation of current energy policies plus a carbon cap modeled on the Waxman-Markey bill; and

iv) Combined Energy Policy - includes the enactment of multiple new energy policies including a carbon cap modeled on the Waxman-Markey bill, a 20 percent Federal RPS requirement, smart grid implementation and the widespread adoption of electric vehicles.

These four scenarios are described more completely in **Schedule TS-02.**

V. PRESENTATION OF RESULTS

Q. Have you prepared schedules summarizing your results?

A. Yes. The results of the analysis are described in Table 1 through Table 9, which are provided in **Schedule TS-03.**

Q. Please describe the Project's impact on Missouri LMPs, as shown in Table 1.

A. The PROMOD analyses involve a comparison of the "with Project" and "without Project" cases for two different study years (2021 and 2026) and four different scenarios within each study year. **Table 1** provides the weighted average LMP values for Missouri from these analyses. Wholesale electric energy prices in Missouri, as measured by the average Missouri LMPs reported in **Table 1,** are lower with the Project in service across all scenarios evaluated. Across these scenarios, the reduction in prices in Missouri from the Project range from $0.35 to

$1.08 per MWh in 2021, and $0.17 to $1.03 per MWh in 2026. The percent reduction in prices ranges from 0.58 to 1.21 percent in 2021, and 0.37 to 1.05 percent in 2026.

Q. Over what geographic areas do you consider changes in production costs?

A. In my analysis, I consider changes in production cost to the entire MISO footprint and to Missouri. Production cost reductions to Missouri provide information about the state-wide impacts to Missouri that are directly relevant to determining whether the Project is in the public interest and economically feasible from the standpoint of Missouri citizens. In addition, changes in production costs are measured for the entire MISO footprint, which captures a broader, regional view of public interest and economic feasibility. Because the MVP portfolio involves projects that are being implemented in states across the MISO footprint, with many states similarly considering approvals that produce both in-state and out-of-state positive benefits (including benefits to Missouri citizens), and because the MVP portfolio was developed as a region-wide, integrated solution, such a broader regional view is appropriate to developing an informed view of whether the Project is in the public interest and whether it is economically feasible.

Q. Please describe the Project's impact on Missouri Production Cost, as shown in Table 2.

A. Production costs in Missouri are lower with the Project in service across all of the scenarios evaluated. Across the scenarios evaluated, the reduction in Missouri Production Costs range from $97.0 million to $229.6 million in 2021, and $104.7 million to $292.0 million in 2026. The percent reduction in Missouri Production Costs ranges from 3.24 to 3.54 percent in 2021, and 3.13 to 3.47 percent in 2026.

Q. Please describe the Project's impact on MISO Production Cost, as shown in Table 3.

A. Production costs in MISO are lower with the Project in service across all of the scenarios evaluated. Across the scenarios evaluated, the reduction in MISO Production Costs range from $201.0 million to $471.1 million in 2021, and $228.5 million to $501.9 million in 2026. The percent reduction in MISO Production Costs ranges from 1.48 to 1.71 percent in 2021, and 1.37 to 1.70 percent in 2026.

Q. Please describe the change in Missouri Net Costs, Tables 4 and 5.

A. **Table 4** presents a conservative depiction of the estimated net cost of the Project that reflects both changes in production costs (over a 20-year period) and MISO Missouri LSEs' estimated share of the transmission charges that will arise from the Project. The net cost reflects the Project's social cost due to changes in production costs and Missouri's share of the Project's development and operation costs. Because the rates charged by Missouri LSEs reflect each entity's cost-of-service and because the Project's costs are recovered through rates charged to the LSEs that serve Missouri customers, these estimates of net costs also provide an appropriate estimate of the changes in electric energy payments by Missouri customers that will arise from the Mark Twain Project. **Table 4** is a one-page summary containing estimates of the reduction in net costs for Missouri from the Project for each of the four scenarios. I refer to these net costs as Missouri Net Costs. **Table 5**, which consists of four pages, provides year-by-year detail of the reductions in production costs and estimates of the present value of these reductions for each of the scenarios.

The Missouri Net Costs of the Project is calculated in several steps. To estimate the annual change in energy costs, I use estimates of Missouri Production Cost changes, which are adjusted to account for net sales and purchases of electric power by these LSEs. Total cost impacts are estimated for the 20-year period, 2019-2038. I selected 2019 as the beginning year for this evaluation since that represents the first year when all elements of the Project are expected to be fully energized. I used the 2021 and 2026 PROMOD-produced electric energy cost amounts to determine a growth rate between these two years, and used this growth rate to interpolate or extrapolate the values for the other years in the 20-year comparison period. The figures in **Table 5** include the nominal annual values and the present value of the total change over the 20-year period as of mid-year 2014, the first year when Project costs were incurred. These discounted present values are computed using alternative discount rates of 3.0 and 8.2 percent, which are the same discount rates used in MISO's MVP Report.

By comparing electric energy production costs in the "with Project" and "without Project" cases, I was able to determine the reduction in customer costs for each scenario (column [A], **Table 4**). As indicated, in **Table 4**, from the estimated total costs for electric energy, I subtracted an estimate of the investment costs for the Project that will be borne by MISO Missouri LSEs through transmission charges arising from the Project, as well as an estimated variable expense component. The remainder provides a conservative estimate of the reduction in net costs that can be expected for Missouri customers as a result of the Project. I characterize the **Table 4** and **Table 5** estimated reductions as conservative because they reflect expected reductions in wholesale electric energy costs, and therefore payments (net of increased transmission payments), but not reductions in costs for other components of electricity supply such as capacity and operating reserves. The estimate also does not account for any reduced electric energy payments prior to 2019 (if portions of the Project come into service at an earlier time). In addition, these estimates also do not account for other social costs and benefits, such as improvements in reliability and reductions in air emissions, which I discuss below. **Schedule TS-02** provides a more detailed explanation of the computational procedures employed in developing **Table 4** and **Table 5**.

Q. What do Table 4 and Table 5 indicate?

A. The results of my analysis reported in **Table 4** and **Table 5** show that the Project will lead to substantial reductions in the ultimate electric rates paid by customers in Missouri as compared to the rates that would be paid without the Project. Under the Business as Usual, Low Demand case, the present value of reductions in wholesale electric energy costs from the Project is $738.6 million (at a discount rate of 8.2 percent). The present value of the transmission charges arising from the Project is $30.0 million, resulting in a net reduction in energy costs to be ultimately borne by Missouri customers of $708.6 million (i.e., $738.6 million minus $30.0 million). Thus, there is almost a 25-to-1 ratio of benefits (in terms of reductions in energy costs) to costs (in terms of Missouri's share of Project costs). The table also shows that the reduction in costs would be even greater under the other scenarios I evaluated, with reductions in net costs for these other three scenarios ranging between $1,008.1 million and $2,029.1 million. When the analysis is performed using a lower 3 percent discount rate, the reduction in net costs increases in each scenario and ranges from $1,375.9 million in the Business as Usual, Low Demand case to $4,072.0 million in the Combined Energy Policy case.

Q: Has MISO developed estimates of economic impacts similar to those developed in your analysis?

A: Yes. MISO has evaluated the economic impact of the MVP portfolio in two studies. One study that was performed prior to approval of the MVP portfolio by the MISO

Board,[15] and a "triennial" update study that was released in 2015.[16] MISO's analysis considers multiple quantified and unquantified economic impacts, including the changes in production cost that I analyze. MISO's analysis differs from mine in one important respect. While my analysis considers the impact of the Project alone (assuming all other MVPs are in service), MISO's analysis considers the impact of all 17 MVPs in the MVP portfolio. Thus, the two analyses provide complementary information on the Project's economic benefits.

Q. Is MISO's analysis of the impact of the MVP portfolio on the MISO region consistent with your findings?

A. Yes. In its original MVP report, MISO concluded that the MVP portfolio would provide $8.8 to $31.0 billion in benefits in excess of costs to the MISO region across scenarios evaluated (in present value terms). In addition, the portfolio would enable the delivery of 41 million MWh of wind energy, which would support achievement of state renewable energy policies.[17] In the triennial update report, MISO estimated net economic benefits of $13.1 billion (present value) from development of the MVP portfolio.[18] These quantified changes in economic costs reflect both reductions in production costs, which are considered in my analysis, as well as other economic impacts that are not considered in my analysis.[19] Thus, as in my

[15] MVP Report.
[16] MISO, "MTEP14 MVP Triennial Review, A 2014 review of public policy, economic, and qualitative benefits of the Multi Value Project Portfolio," September 2014 ("Triennial Report").
[17] All MISO study results reported in this testimony assume an 8.2% discount rate and benefits over a 20-year horizon. Results from the 2012 study are reported in 2011 dollars, while results from the Triennial Study are reported in 2014 dollars. MVP Report, pp. 49, 69.
[18] The Triennial Report evaluated the business as usual high and low demand scenarios, with the reported value reflecting an average of these two scenarios. Triennial Report; "MTEP14 MVP Triennial Review Business Case.xlsx."
[19] These other benefits include reductions in operating reserve and capacity requirements, wind turbine investment and future transmission investment.

analysis, MISO finds that the Project – as an element of the MVP portfolio – provides net benefits to the MISO region.

Q. Is MISO's analysis of the impact of the MVP portfolio on Missouri consistent with your findings?

A. Yes. Along with analyzing impacts across the entire MISO footprint, MISO also assesses the impact of the MVP portfolio for each of seven individual "zones" that comprise MISO, one of which is the Missouri portion of MISO (see, e.g., page 7 of the MISO MVP Report). The MISO report concludes that there are substantial benefits from the MVP portfolio in each zone, thus indicating that the MVP portfolio will provide widespread benefits to all regions within the MISO footprint. In both the MVP report and the Triennial Update, MISO finds that the benefits to Missouri from the development of the MVP portfolio would far outweigh the associated costs of developing the portfolio. In the original MVP Report, MISO finds that the MVP portfolio would result in net benefits of $748 million to MISO Missouri, with a ratio of benefits to costs ranging from 1.8 to 3.2 across scenarios.[20] In the Triennial Report, MISO found that benefits to Missouri would total $1.15 billion (present value), with a ratio of benefits to costs equal to 2.33.[21] Thus, as in my analysis, MISO finds that the Project – on its own or as an element of the MVP portfolio – provides substantial net benefits to Missouri.

Q. Please describe the Project's impact on air emissions, Table 6 through Table 9.

A. The impact of the Project on emissions of CO_2, NO_X, SO_2, and mercury are shown in **Table 6** to **Table 9**. Across all of the scenarios, air emissions fall with the introduction

[20] Net benefits are reported for a nominal scenario, reflecting an average of business as usual high and low demand scenarios. MVP Report, p. 86; "MVP Detailed Base Case.xlsx."
[21] "MTEP14 MVP Triennial Review Business Case.xlsx."

of the Project. As shown in **Table 6**, when the Project is in service, MISO CO_2 Emissions fall by 3.7 to 4.4 million tons of CO_2 equivalent ("TCO_2e") in 2021, and 2.5 to 4.2 million TCO_2e in 2026. These reductions reflect a 1.14 to 1.35 percent reduction in 2021, and 0.91 to 1.15 percent reduction in 2026. Changes in Missouri NO_X, SO_2 and Mercury Emissions are similar in percentage terms. For example, the percent reduction in Missouri NO_X Emissions reported in **Table 7** is 1.01 to 1.28 percent in 2021, and 0.84 to 1.20 percent in 2026. Reductions in in-state emissions from the Project occur despite the fact that total power generated by in-state sources rises when the Project is in service. For example, in the Business as Usual: Low Demand case, in-state power generation increases by 2.1 TWh in 2021 and 2.0 TWh in 2026, representing 1.93 and 1.79 percent increases in total in-state generation. However, despite this increase in output, Missouri NO_X Emissions fall by 1.1% in 2021 and 1.2 percent in 2026, Missouri SO_2 Emissions fall by 0.9 percent in 2021 and 0.9 percent in 2026 (**Table 8**), and Missouri Mercury Emissions decline by 0.8 percent in 2021 and 1.0 percent in 2026 (**Table 9**). These reductions in air emissions further demonstrate that the Project is in the public interest.

Q. Does this conclude your direct testimony?

A. Yes, it does.

BEFORE THE PUBLIC SERVICE COMMISSION
OF THE STATE OF MISSOURI

In the Matter of the Application of Ameren Transmission Company of Illinois for Other Relief or, in the Alternative, a Certificate of Public Convenience and Necessity Authorizing it to Construct, Install, Own, Operate, Maintain and Otherwise Control and Manage a 345,000-volt Electric Transmission Line from Palmyra, Missouri, to the Iowa Border and an Associated Substation Near Kirksville, Missouri.	)	File No. EA-2015-0146

AFFIDAVIT OF TODD SCHATZKI

STATE OF MASSACHUSETTS)
) ss
CITY OF BOSTON)

Todd Schatzki, being first duly sworn on his oath, states:

1. My name is Todd Schatzki. I work in Boston, Massachusetts, and I am employed by Analysis Group, Inc.

2. Attached hereto and made a part hereof for all purposes is my Direct Testimony on behalf of Ameren Transmission Company of Illinois consisting of 24 pages, and Schedule(s) TS-01, TS-02, and TS-03 all of which have been prepared in written form for introduction into evidence in the above-referenced docket.

3. I hereby swear and affirm that my answers contained in the attached testimony to the questions therein propounded are true and correct.

Todd Schatzki

Subscribed and sworn to before me this 21 day of May, 2015.

Notary Public

My commission expires:

DENISE VAN VOOREN
Notary Public
Massachusetts
Commission Expires Nov 3, 2017

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Dr. Schatzki is an expert in energy and environmental economics and policy, and specializes in the application of microeconomics, econometrics, and data analysis to complex business and policy problems. He has worked with clients on corporate strategy, public policy design, and problems arising in regulation and litigation.

Dr. Schatzki has worked extensively on the design of electricity markets, analysis of wholesale electricity markets, economic analysis of energy and environmental regulations, asset valuation, resource planning and procurement, utility ratemaking and retail electricity markets. He has submitted testimony to both state and federal energy commissions. His research has been supported by organizations such as the Electric Power Research Institute, Edison Electric Institute, Federal Energy Regulatory Commission, and National Association of Regulatory Utility Commissioners. His work has appeared in journals such as the *Journal of Environmental Economics and Management, the Electricity Journal, Public Utilities Fortnightly,* and *AEI-Brooking Joint Center for Regulatory Studies.* He has also provided litigation support in many cases, including several high profile cases involving alleged wholesale electricity price manipulation and the implications of such manipulation for derivative contracts.

Prior to joining Analysis Group, he had research and consulting affiliations with the Harvard Institute for International Development and the International Institute for Applied Systems Analysis (Vienna, Austria), and was an economist at LECG, LLC and National Economic Research Associates.

EDUCATION

1998 Ph.D., Public Policy, Harvard University, Cambridge, MA

Specialized Fields: Microeconomics, econometrics, industrial organization, natural resource and environmental economics

- Doctoral Fellow, Harvard University, Cambridge, MA (1993-1995)
- Crump Fellowship, Harvard University, Cambridge, MA (1995-1996)
- Pre-doctoral Fellow, Harvard Environmental Economics Program

1993 M.C.P., Environmental Policy and Planning (Urban Studies and Planning,), M.I.T., Cambridge, MA

1986 B.A., Physics, Wesleyan University, Middletown, CT

SCHEDULE TS-01

PROFESSIONAL EXPERIENCE

2005-present	Analysis Group, Inc.
2001-2005	LECG, LLC, *Managing Economist*
1998-2001	National Economic Research Associates, Inc., *Senior Consultant*
1997-1998	Harvard Institute for International Development, *Consultant*
1996-1997	Department of Economics, Harvard University, *Teaching Fellow and Research Assistant*
1994	International Institute for Applied Systems Analysis (IIASA)
1992	Toxics Reduction Institute, University of Massachusetts
1987-1991	Tellus Institute, *Research Associate*

SELECTED CASE WORK

Energy

- **New York Independent System Operators.** Evaluation of capacity market rule changes including a forward market structure and multi-year price lock-in, including quantitative economic analysis of changes in market outcomes under alternative market structures.
- **ISO New England.** Assistance to the ISO New England market monitor in the development of a de-list offer model consistent with new market rules.
- **ISO New England.** Assistance in the development of a Winter 2013/2014 fuel assurance programs, including oil inventory, dual fuel, liquefied natural gas and demand response programs
- **Ameren Transmission.** Analysis of the impact of the Multi Value Project No. 16, a new transmission project, on energy market competition in Illinois (using PROMOD).
- **Vancouver Energy.** Assessment of economic impacts of a new energy distribution terminal, including change in economic activity, property value impacts and changes in rail congestion
- **ISO New England.** Assessment of the economic costs associated with winter 2013/2014 reliability programs, including oil inventory, dual fuel, liquefied natural gas and demand response programs
- **ISO New England.** Assessment of and testimony regarding the economic and reliability impacts of proposed capacity market rules introducing new performance incentives
- **ITC Midwest.** Analysis of and testimony regarding the LMP and production cost impacts of new transmission infrastructure (using PROMOD)
- **Entergy.** Evaluation of economic damages associated with an alleged contract breach
- **Ameren Transmission.** Analysis of the impact of the Illinois River Project, a new transmission project, on energy market competition in Illinois (using PROMOD)
- **Dayton Power and Light.** Evaluation of the aggregate benefits created by a proposed rate plan
- **Corporation with distribution companies across multiple jurisdictions.** Regulatory assessment considering current ratemaking models, regulatory environment and alternative ratemaking structures

SCHEDULE TS-01

- **ISO New England.** Assessment of the costs, feasibility and effectiveness of technical options to securing fuel supply for gas-fired generators
- **ISO New England.** Assessment of reliability risks and potential market and regulatory solutions to electric-gas interdependencies
- **Pacific Gas and Electric.** Assessment of ratemaking issues, including cost of capital adjustments, associated with a gas pipeline safety plan
- **Confidential Technology Company.** Analyzed the regional economic impacts of a prototype biofuels production facility at two potential development sites using the IMPLAN model.
- **ISO New England.** Statistical analysis of the performance of resources responding to system contingencies
- **Direct Energy.** Assistance developing regulatory options for promoting retail competition in Pennsylvania, including development of customer service auctions
- **ISO New England.** Assistance developing design enhancements for the region's Forward Reserve Markets
- **Confidential Client.** Analysis of energy and capacity market implications of a potential asset agreement (using GE's Multi-Area Production Simulation Software)
- **Confidential Client.** Analysis of fleet turnover decisions and outcomes (using GE's Multi-Area Production Simulation Software)
- **Confidential Regulated Utility.** Development of a white paper on transmission planning and policy needed to support legislative and regulatory goals for renewable development
- **Commonwealth Edison.** Analysis of appropriate ratemaking tools (cost of equity adjustment) in light of energy efficiency program requirements
- **New England Power Generators Association.** Analysis of impacts of proposed electric power company merger
- **Confidential Technology Company.** Development of a quantitative model of energy savings associated with end-use technological modifications..
- **Confidential Regulated Utility.** Development of a white paper assessing the potential for alternative ratemaking tools to mitigate multiple utility capital, load and service challenges
- **EDF Group.** Analysis of financial and credit implications of the sale of a portion of power generation assets
- **New England States Committee on Electricity.** Technical support and analysis related to design of regulations and wholesale electricity markets to achieve resource adequacy
- **National Grid Utilities.** Assistance developing ratemaking plans including revenue decoupling and associated revenue adjustments
- **NARUC and FERC.** Analysis of "best practices" in state policies for competitive procurement of retail electricity supply
- **New York ISO.** Analysis of single-clearing-price versus pay-as-bid market designs
- **Confidential System Operator.** Analysis of metrics for characterizing the economic value provided by regional transmission organizations
- **TransCanada.** Assessment of regulatory and finance issues involved in fuel adjustment clauses within long-term standard offer service contracts
- **New York ISO.** Analysis of market implications of fuel diversity issues

- **Confidential.** Analysis of alleged exercise and extension of market power in a wholesale electricity market, including statistical analysis of spot and real-time electricity markets and statistical modeling of outages using hazard model methods to examine potential physical withholding
- **Confidential.** Financial and strategic analysis of gas supply contracting alternatives
- **Confidential.** Analysis of value of generating assets using real options analysis
- **Confidential.** Statistical analysis of prices in the spot and forward markets using time-series methods for an energy trading firm in a federal proceeding related to the reasonableness of the terms of certain forward market contracts
- **Confidential.** Financial and strategic analysis of renewable generation technologies

Environment

- **ExxonMobil.** Assessment of methods for valuation of environmental contamination.
- **Chevron.** Development of a white paper on post-2020 climate policy for California
- **American Petroleum Institute.** Assessment of issues related to the impact of changes to National Ambient Air Quality Standard Requirements on oil and gas exploration and production
- **Greater Boston Real Estate Board.** Development of a white paper on mandatory building energy labeling/benchmarking policies
- **Little Hoover Commission.** Analysis of the economic and environmental consequences of a local climate policy plan implemented in the context of a state-wide cap-and-trade system
- **Exelon.** Analysis of the economic and market consequences of EPA's Clean Air Transport Rule
- **Chevron.** Assessment of lessons learned from Federal requirements for regulatory review for the potential development of state requirements
- **Western States Petroleum Association and Chevron.** Regulatory support and analysis related to climate policy in California, including submission of various comments and reports to the Air Resources Board
- **Honeywell.** Analysis of proposed limits on HFC consumption under domestic climate policy
- **Electric Power Research Institute.** Analysis of three 2006 studies on the economic impact of meeting the California carbon emissions reduction targets (in the California Global Warming Solutions Act of 2006)
- **Confidential.** Assessment of various policy issues in the design of national climate change policies, including market-based policies, approaches to cost containment, offset projects, and non-CO_2 GHGs
- **Confidential.** Quantitative analysis of the impacts for technology, consumers and asset owners of a market-based domestic climate policy
- **Toyota.** Analysis of the economic value of emissions for a major auto manufacturer associated with alleged non-compliance with emissions control requirements
- **Barajas Airport.** Evaluated the regional economic impacts of runway expansions at the Barajas airport in Spain.

Finance and Commercial Damages

- Analysis of financial and credit implications of the sale of a portion of power generation assets
- Analysis of bond pricing, transactions and holdings related to default of sovereign bonds
- Analysis of transfers between financial institutions within credit card networks
- Analysis of the impact of product taxes on firm market shares related to determination of payments under a settlement agreement
- Analysis of damages related to breached contract and appropriation of trade secrets in the development of a pharmaceutical product
- Analysis of damages from breach of commodity swap contract (petroleum)
- Analysis of allegations regarding mutual fund day trading, including analysis of trading patterns and calculation of dilution

Antitrust

- Estimation of damages associated with an alleged monopolization and foreclosure resulting from a distribution agreement (retail consumer products)
- In a price-fixing case across multiple markets in the pharmaceutical industry, estimated overcharges and cartel periods based on a time-series analysis of price data
- Analysis of multiple antitrust claims (including foreclosure, monopolization, and vertical restraints) related to an alleged collusive distribution arrangement (retail consumer product)
- Analysis of alleged tying of aftermarket products and the provision of service, including evaluation of the alleged tie, competitive effects, and damages (office systems)
- Analysis of liability, timing, geographic scope, and damages issues for a petrochemical company facing potential price-fixing charges by DOJ and private parties
- Analysis of tying, monopolization, and patent abuse claims involving a patent licensing scheme for process and instrument patents (scientific equipment)
- Analysis of foreclosure, attempted monopolization of innovation markets, and damages claims arising from the termination of an investment/licensing agreement (medical devices)
- Estimation of damages related to alleged invalid patents and tying of products to patent rights associated with a process patent (scientific equipment)

ARTICLES AND PAPERS

Beyond AB 32: Post-2020 Climate Policy for California (with Robert N. Stavins), *Regulatory Policy Program, Mossavar-Rahmani Center for Business and Government, Harvard Kennedy School,* January 2014.

Three Lingering Design Issues Affecting Market Performance in California's GHG Cap-and-Trade Program (with Robert N. Stavins), *Regulatory Policy Program, Mossavar-Rahmani Center for Business and Government, Harvard Kennedy School,* January 2013.

Using the Value of Allowances from California's GHG Cap-and-Trade System (with Robert N. Stavins), *Regulatory Policy Program, Mossavar-Rahmani Center for Business and Government, Harvard Kennedy School,* August 27, 2012.

Implications of Policy Interactions for California's Climate Policy (with Robert N. Stavins), *Regulatory Policy Program, Mossavar-Rahmani Center for Business and Government, Harvard Kennedy School,* August 27, 2012.

"The Interdependence of Electricity and Natural Gas: Current Factors and Future Prospects," (with Paul Hibbard), *The Electricity Journal*, May 2012.

"California's Cap-and-Trade Decisions," Forbes.com, August 19, 2010.

"Competitive Procurement of Retail Electricity Supply: Recent Trends in State Policies and Utility Practices," (with Susan F. Tierney), *The Electricity Journal*, March 2009.

"Pay-as-Bid vs. Uniform Pricing: Discriminatory Auctions Promote Strategic Bidding and Market Manipulation" (with Susan F. Tierney and Rana Mukerji), *Public Utilities Fortnightly*, March 2008.

"Free Greenhouse Gas Cuts: Too Good to Be True?" (with Judson Jaffe and Robert Stavins) VoxEU.org, January 3, 2008.

"Too Good to Be True? An Examination of Three Economic Assessments of California Climate Change Policy" (with Robert N. Stavins and Judson Jaffe), AEI-Brookings Joint Center for Regulatory Studies, Related Publication 07-01. Jan 2007.

"Options, Uncertainty and Sunk Costs: An Empirical Analysis of Land Use," Journal of Environmental Economics and Management, Vol. 46, p. 86-105, 2003.

"The database on the economics and management of endangered species (DEMES)," (with David Cash, Andrew Metrick, and Martin Weitzman) in *Protecting Endangered Species in the United States: Biological Needs, Political Realities, Economic Choices*. Cambridge University Press, 2001

"The Issue of Climate," *Fundamentals of the Global Power Industry, Petroleum Economist, 2000.*

Review of "Sustainable Cities: Urbanization and the Environment in International Perspective," *Environmental Impact Assessment Review*, (Vol. 12, No, 4), 1993.

"Bottle Bills and Municipal Recycling," *Resource Recycling*, June 1991.

WORKING PAPERS

"Quality *and* Quantity: Alternatives for Addressing Reliability Concerns from Shifting Resource Mixes," June 23, 2014.

"Reliability and Resource Performance," May 16, 2012.

"Can Cost Containment Raise Costs? Allowance Reserves in Practice," March 2012.

Schatzki, Todd, Paul Hibbard, Pavel Darling and Bentley Clinton, Generation Fleet Turnover in New England: Modeling Energy Market Impacts, June, 2011.

"A Hazard Rate Analysis of Mirant's Generating Plant Outages in California," with William Hogan and Scott Harvey. Presented at the IDEI Conference on Competition and Coordination in the Electricity Sector, Toulouse, France, January 16-17, 2004.

"Estimating Structural Change in Industries with Application to Cartels," June 2003.

"The Pollution Control and Management Response of Thai Firms to Formal and Informal Regulation," (with Theodore Panayotou) draft, 1999.

"Differential Industry Response to Formal and Informal Environmental Regulations in Newly Industrializing Economies: The Case of Thailand," (with Theodore Panayotou and Qwanruedee Limvorapitak), Harvard Institute for International Development 1997 Asia Environmental Economics Policy Seminar, Bangkok, Thailand, February 1997.

"The Effects of Uncertainty on Landowner Conversion Decisions," John F. Kennedy School of Government, Center for Science and International Affairs, Environment and Natural Resources Program, Discussion Paper 95-14, December 1995.

SELECTED PRESENTATIONS

"Market Changes to Promote Fuel Adequacy – Capacity Markets to Promote Fuel Adequacy," panel discussion, Northeast Energy Summit 2014, September 17-19, 2014.

"Quality *and* Quantity: Alternatives for Addressing Reliability Concerns from Shifting Resource Mixes," Center for Research In Regulated Industries 27th Annual Western Conference June 26, 2014.

"Climate Policy Choices – RPS, Cap-and-Trade & the Implications for Actions (and Exits) that Affect Emissions," Electric Utilities Environmental Conference, February 4, 2014.

"Multiple Dimensions of Gas-Electric Coordination Concerns," Electric Utilities Environmental Conference, February 3, 2014.

"The Economics of Cap-and-Trade in the California Power Markets," EUCI Conference, California Carbon Policy Impacts on Western Power Markets, January 27, 2014.

"Market-Based Policies to Address Climate Change," Sustainable Middlesex, May 4, 2013.

"Market Forces and Prospects/Economic Ripple Effects, 5-10 Years Ahead," Air & Waste Management Association, New England Section, October 12, 2012.

"Gas and Electric Coordination: Is It Needed? If So, To What End?" Harvard Electric Policy Group, Cambridge, MA, October 11, 2012.

"Reliability and Resource Performance," Center for Research In Regulated Industries 31st Annual Eastern Conference May 16, 2012.

"Can Cost Containment Raise Costs? Allowance Reserves in Practice," International Industrial Organization Conference, Boston, MA, April 9, 2011.

"Ratemaking Mechanisms/Tools as Carrots for Achieving Desirable Regulatory Outcomes," Conference on Electric Utility Rate Cases, Law Seminars International, Boston, Massachusetts, November 9, 2010.

"Evolving Issues in Revenue Decoupling: Designs for an Era of Rising Costs," Center for Research In Regulated Industries 29th Annual Eastern Conference May 19, 2010.

"Aligning Interest with Duty: Revenue Decoupling as a Key Element of Accomplishing Energy Efficiency Goals," National Conference of State Legislatures, Fall Forum, December 8, 2009.

"Federal Proposals to Limit Carbon Emissions and How They Would Affect Market Structures – Regional Trading Programs' Futures in Light of New Federal Interest in Reducing GHG Emissions," Energy in California, Law Seminars International, San Francisco, California, September 15, 2009.

"Current Market, Technology and Regulatory Risks: Impact on Investment and Implications for Policy", Utility Rate Case, Issues and Strategy 2009, Law Seminars International, Las Vegas, Nevada, February 9, 2009.

"An Economic Perspective on the Benefits of Going Green," Harvard Electricity Policy Group, Atlanta, Georgia, December 11-12, 2008.

"Implications of Current Regulatory, Technology and Market Risks," Energy in California, Law Seminars International, San Francisco, California, September 22-23, 2008.

"Competitive Procurement of Retail Electricity Supply: Recent Trends in State Policies and Utility Practices," National Association of Regulatory Utility Commissioners Summer Committee Meetings, Portland, Oregon, July 20, 2008.

"Too Good to Be True? An Examination of Three Economic Assessments of California Climate Change Policy, Key Findings and Lessons Learned," POWER Research Conference on Electricity Markets and Regulation, University of California at Berkeley, March 21, 2008.

"Preliminary Findings: Study of Model State and Utility Practices for Competitive Procurement of Retail Electric Supply," National Association of Regulatory Utility Commissioners Annual Meeting, Washington, D.C., February 17, 2008.

"The ABC's of California's AB 32: Issues and Analysis, Cost Analyses and Policy Design" Environmental Market Association Webinar, April 12, 2007.

SELECTED CONSULTING REPORTS

Assessment of the Impact of ISO-NE's Proposed Forward Capacity Market Performance Incentives (with Paul Hibbard), prepared for ISO New England, September 2013.

"LMP Impacts of Proposed Minnesota-Iowa 345 kV Transmission Project: Supplemental Analysis," with Rodney Frame and Pavel Darling, Appendix M, ITC Midwest LLC, Application to the Minnesota Public Utilities Commission for a Certificate of Need, Docket No. ET6675/CN-12-1053, April 9, 2013.

"LMP Impacts of Proposed Minnesota-Iowa 345 kV Transmission Project," with Rodney Frame and Pavel Darling, Appendix M, ITC Midwest LLC, Application to the Minnesota Public Utilities Commission for a Certificate of Need, Docket No. ET6675/CN-12-1053, March 22, 2013.

"Analysis of Reserve Resources: Activation Response following Contingency Events," prepared for ISO New England, May 29, 2012.

Economic and Environmental Implications of Allowance Benchmark Choices (with Robert N. Stavins), prepared for the Western States Petroleum Association, October 2011.

Next Steps for California Climate Policy II: Moving Ahead under Uncertain Circumstances (with Robert N. Stavins), prepared for the Western States Petroleum Association, April 2010.

Options for Addressing Leakage in California's Climate Policy (with Jonathan Borck and Robert N. Stavins), prepared for the Western States Petroleum Association, February 2010.

Addressing Environmental Justice Concerns in the Design of California's Climate Policy (with Robert N. Stavins), prepared for the Western States Petroleum Association and the AB 32 Implementation Group, November 2009.

Next Steps for California with Federal Cap-and-Trade Policy On the Horizon (with Robert N. Stavins and Jonathan Borck), prepared for the Western States Petroleum Association, July 2009.

Evolving GHG Trading Systems Outside Its Borders: How Should California Respond? (with Robert N. Stavins and Jonathan Borck), prepared for the Western States Petroleum Association, July 2009.

Competitive Procurement of Retail Electricity Supply: Recent Trends in State Policies and Utility Practices, (with Susan Tierney) prepared for the National Association of Regulatory Utility Commissioners in collaboration with the Federal Energy Regulatory Commission, July 2008.

Uniform Pricing versus Pay-as-bid: Does it Make a Difference?, (with Susan Tierney and Rana Mukerji) prepared for the New York Independent System Operator, March 2008.

Prospects for the U.S. Nuclear Industry, (co-author), prepared for a major Japanese electric power company, January 2001.

Costs and Benefits of Fish Protection Alternatives at Mercer Generating Station, (with David Harrison and Michael Lovenheim), prepared for Public Service Enterprise Group, September 2000.

Economic Evaluation of EPA's Proposed Rules for Cooling Water Intake Structures for New Facilities, (with David Harrison) prepared for the Utility Water Act Group, November 2000.

The Impacts of Revised Salem Refueling Schedules on the Wholesale and Retail Electric Market, (with David Harrison and Gene Meehan) prepared for Public Service Enterprise Group as a filing to New Jersey Department of Environmental Protection, September 2000.

Setting Baselines for Greenhouse Gas Credit Trading Programs: Lessons from Experience with Environmental and Non-Environmental Program, (with David Harrison) Electric Power Research Institute Report #1000147, December 2000.

Fueling Electricity Growth for a Growing Economy, Background Paper, (with David Harrison) prepared for the Edison Electric Institute, July 2000.

Energy-Environment Policy Integration and Coordination Study (E-EPIC) Phase 2 Executive Report (Contributor), Electric Power Research Institute, Technical Report 1000097, December 2000.

Economic Evaluation of Alternative Revised Refueling Outage Schedules for Salem Power Plant, (with D. Harrison and J. Murphy), prepared for Public Service Electric and Gas Company as a filing to New Jersey Department of Environmental Protection, July 2000.

Critical Review of "Economic Impacts of On Board Diagnostic Regulations," (with D. Harrison and S. Chamberlain) prepared for Alliance of Automobile Manufactures, January 2000.

Costs and Benefits of Alternative Revised Refueling Outage Schedules, (with D. Harrison and J. Murphy), prepared for Public Service Electric and Gas Company, July 1999.

Costs and Benefits of Fish Protection Alternatives at the Salem Facility, (with D. Harrison and J. Murphy) prepared for Public Service Electric and Gas Company as a filing to New Jersey Department of Environmental Protection, March 1999.

Energy-Environment Policy Integration and Coordination Study (E-EPIC) Phase 1 Executive Report, (Contributor) Electric Power Research Institute, February 1999.

Economic Benefits of Barajas Airport to the Madrid Region and the Neighboring Communities, (with D. Harrison, J. Garcia-Cobos, and D. Rowland) prepared on behalf of the Spanish Government, January 1999.

Costs and Benefits of Alternatives for Modifying Cooling Water Intake at the Hudson Facility, (with D. Harrison, D. Rowland and J. Murphy), prepared for Public Service Electric and Gas Company, November 1998.

Disposal Cost Fee Study, (with Frank Ackerman, Gretchen McClain, Irene Peters, and John Schall) prepared for the California Integrated Waste Management Board, 1991.

The Marginal Cost of Handling Packaging Materials in the New Jersey Solid Waste System, (with John Schall) prepared for The Council of State Governments and the New Jersey Department of Environmental Protection, 1990.

Energy Implications of Alternative Solid Waste Management Systems, (with Monica Becker and Allen White), prepared for the Northeast Regional Biomass Program, Coalition of Northeastern Governors Policy Research Center, 1990.

TESTIMONY AND OTHER FILINGS

Rebuttal Testimony on behalf of Ameren Transmission Company of Illinois, Illinois Commerce Commission, Docket No. 14-0514, March 5, 2014.

Direct Testimony on behalf of MidAmerican Transmission Company, Illinois Commerce Commission, Docket No. 14-0494, March 5, 2014.

Direct Testimony on behalf of Ameren Transmission Company of Illinois, Illinois Commerce Commission, Docket No. 14-0514, August 21, 2014.

Direct Testimony on behalf of MidAmerican Transmission Company, Illinois Commerce Commission, Docket No. 14-0494, August 4, 2014.

Rebuttal Testimony on behalf of ITC Midwest LLC, Minnesota Public Utilities Commission, Docket No. CN-12-1053, April 25, 2014.

Direct Testimony on behalf of ITC Midwest LLC, Minnesota Public Utilities Commission, Docket No. CN-12-1053, February 24, 2014.

Testimony on behalf of the ISO New England, FERC Docket No. ER14-1050-001, February 12, 2014.

Affidavit on behalf of the ISO New England, Performance Incentives Market Rule Changes, FERC Docket No. ER14-1050-001, January 14, 2014.

Comments submitted to the California Air Resources Board Regarding on the Proposed Regulation to Implement the AB 32 Cap-and-Trade Program, August 2011 (with Robert N. Stavins).

Comments submitted to the Little Hoover Commission's Study of Regulatory Reform in California, January 2011 (with Robert N. Stavins).

Comments submitted to the California Air Resources Board Regarding on the Proposed Regulation to Implement the AB 32 Cap-and-Trade Program, December 2010.

Comments submitted to the California Air Resources Board Regarding Cost Containment Provisions of Preliminary Draft Cap-and-Trade Regulation, July 2010.

Comments submitted to the Economics and Allocation Advisory Committee, California Air Resources Board regarding draft report "Allocating Emissions Allowances Under California's Cap-and-Trade System," December 1, 2009 (with Robert N. Stavins).

Schedule TS-02:

Technical Appendix: PROMOD Modeling and Data

This exhibit provides a summary of the PROMOD IV ("PROMOD") model, data and assumptions used in analyzing the Mark Twain transmission project (the "Project") proposed by Ameren and the methodology for estimating the effect of this project on wholesale electric energy prices and supply to Missouri.[1]

The PROMOD Model

PROMOD is an electric market simulation model marketed by Ventyx. PROMOD provides a geographically and electrically detailed representation of the topology of the electric power system, including generation resources, transmission resources, and load. This detailed representation allows the model to capture the effect of transmission constraints on the ability to flow power from generators to load, and thus calculates Locational Marginal Prices ("LMPs") at individual nodes within the system. PROMOD and similar dispatch modeling programs are used to forecast electricity prices, understand transmission flows and constraints, and predict generation output. It can also perform and support various reliability analyses, including calculation of loss-of-load probability, expected unserved energy, and effective capacity support.

Data and Assumptions

The analysis of the Project relies on data developed by the Midcontinent Independent System Operator, Inc. ("MISO") in its Multi Value Project ("MVP") process. A detailed description of MISO's MVP process and data analysis is provided in the MVP Report.[2] The principal purpose of the MVPs is, as described by MISO, "to meet one or more of three goals: reliably and economically enable regional public policy needs; provide multiple types of

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[1] The Missouri region analyzed captures all Missouri loads, including the Missouri portions of companies that span multiple states, as determined by the proportion of retail sales in Missouri.

[2] MISO, *Multi Value Project Portfolio: Results and Analyses*, January 10, 2012 (hereafter "MVP Report").

economic value; and provide a combination of regional reliability and economic value."[3] To support the identification of these transmission projects, MISO has performed detailed economic and engineering analyses of many alternative transmission projects and portfolios using PROMOD, along with other engineering tools and analyses. The analyses herein are based on the same data sets and analyses developed by MISO to perform its analysis.

The data and assumptions used by MISO in its MVP analysis are based on Ventyx-provided data, and have been modified as needed by MISO. This data includes:

1. load forecasts provided by individual load serving entities ("LSE") within MISO,[4]
2. transmission line data from transmission operators,[5]
3. unit specifications for existing generation resources,[6]
4. new generation resources based on units planned and under construction,[7]
5. future generation resource additions developed by a capacity expansion model,[8]
6. retirement of generation facilities based on currently announced retirements, but not in response to economic or regulatory factors, including EPA regulation,[9]
7. "hurdle rates" for transactions between NERC regions,[10] and

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[3] MISO website, available at https://www.midwestiso.org/Planning/Pages/MVPAnalysis.aspx, accessed July 22, 2014.

[4] Demand and energy growth rates for each region are provided in: MISO, *MISO Transmission Expansion Plan 2011: PROMOD Case Assumptions Document*, p 23 ("MTEP PROMOD Assumptions" hereafter).

[5] Transmission constraints are based on the then-most recent Book of Flowgates from MISO and North American Electric Reliability Corporation (NERC), updated to include rating and configuration changes from studies performed during the MTEP 11 process. Transmission line data includes items such as the voltage rating of the line and the buses that each line runs between.

[6] Individual unit specifications include maximum operating capacity; fuel type; variable costs; no-load and startup costs; minimum run times; emission rates; and heat rate curves.

[7] Detailed information on the existing, under construction and planned units in each region is provided in MTEP PROMOD Assumptions, p 17.

[8] MISO relies upon the Electric Generation Expansion Analysis System (EGEAS) model developed by the Electric Power Research Institute. EGEAS is designed to find the optimized capacity expansion plan to meet forecast demand (load plus planning reserve margin target minus losses) through a least cost-mix of supply-side and demand-side resources. Planning reserve margins are identified in MTEP PROMOD Assumptions, pp 23-24.

[9] As part of MTEP 2011, MISO has performed an EPA Regulation Impact Analysis that identifies planning needs arising from the retirement of coal-fired generation facilities due to EPA regulations and other market factors (*e.g.*, competition from natural gas-fired generation). MISO's MVP analysis does not incorporate any retirements of coal-fired generation, aside from already announced retirements.

8. fuel and emission price forecasts.

The system modeled includes individual generator data and complete transmission information for the Eastern Interconnection,[11] at the bus[12] level. Thus, the model provides estimates of the loads, production decisions and wholesale market outcomes that for the entirety of the state of Missouri, including the MISO, SPP and other systems. As modelled within PROMOD, Missouri is represented by eight "areas", which reflect aggregations of LSE service territories, including five areas that are solely within Missouri and three areas that span Missouri and adjacent states.

The quantity and location of future renewable resources, including wind and solar, are determined by MISO both to meet state renewable energy requirements and to reduce the combined cost of renewable and transmission resources.[13] Based on these requirements, MISO's analysis assumes that 8,765 MW of new wind resources are added by 2021, and an additional 2,272 MW of new wind resources are added by 2026.[14]

The Project would include transmission facilities that will be routed south from the Missouri-Iowa border to the proposed ATXI Zachary substation near Kirksville, Missouri, and then westerly on to the Maywood switching station. I also understand that the Project would include 95 miles of new 345-kV transmission line, a new 345-kV terminal and 345/161 kV step-down transformer at the new Zachary substation , and a 161-kV connector line running from the Zachary substation to Ameren Missouri's existing Adair substation.

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[10] PROMOD allows power to flow between regions based on economic transactions (subject to security constraints and congestion) such that prices must exceed generator costs in a neighboring region by a dollar per MWh "hurdle rate" in order for power to flow across regions.

[11] The Eastern Interconnection comprises roughly the eastern two-thirds of the "lower 48" (excluding portions of Texas), including the Canadian provinces east of Alberta and the following NERC regions: Midwest Reliability Organization (MRO), Southwest Power Pool (SPP), SERC Reliability Corporation (SERC), Florida Reliability Coordinating Council (FRCC), Reliability*First* Corporation (RFC), and Northeast Power Coordinating Council (NPCC). MISO's PROMOD modeling excludes Peninsular Florida, New England, and Eastern Canada, but accounts for aggregate regional flows to and from these areas through the use of fixed transactions. For more detail, see MTEP PROMOD Assumptions, p 24.

[12] A bus is the specific geographical point that a generator is located at or that a transmission line connects to.

[13] MISO determined the amount of wind enabled by the MVP portfolio by first determining the amount of wind needed to comply with state renewable energy requirements, and then determining what amount of wind would not be supported but for the MVP portfolio. This process is detailed by MISO in the MVP Report, pp 17-20 and 48-49.

[14] Table 4.2, MVP Report. MISO also finds that the MVP portfolio can support an additional 2,230 MW of additional wind power from the wind zones without incurring additional reliability constraints. MVP Report, pp 48-49.

The Project includes nearly all of MVP 8 and the Missouri portion of MVP 7. MVP 7 and 8 are shown geographically in Figure 1. The analysis of the Project herein compares scenarios with and without MVP 7 and 8, which is an appropriate assumption because the Iowa portions of MVP 7 are not electrically interconnected with any other elements of the transmission system. All scenarios evaluated include all of the other MVPs in MISO's MVP portfolio – that is, MVPs 1 to 6, and 9 to 17.[15]

Apart from the presence of the Project itself, the only other difference between the "with Project" and "without Project" cases is the capacity of wind resources in service. In the "without Project" case, the quantity of new wind resources has been reduced because the transmission system cannot support all new MVP wind resources without introducing reliability risks. Unless new wind additions are reduced, power flows may exceed line capacities under certain contingencies. To determine the quantity of wind capacity that can be supported, MISO performs an analysis that identifies the minimum quantity of wind capacity reductions that allow line loading to be kept within limits.[16] Table 1 reports the difference in dispatched wind power capacity between the "with Project" and "without Project" cases for affected resources based on analysis by MISO.[17]

[15] These "other" MVPs are identified in Table 1.1 of the MVP Report.

[16] For further detail on this analysis, see MVP Report at p 48.

[17] Direct communication with MISO, March 11, 2015. The wind zones identified in Table 1 refer to wind zones defined by MISO through its wind siting strategy. For more detail, see MVP Report at pp 17-18.

Figure 1

Map of MVP Portfolio

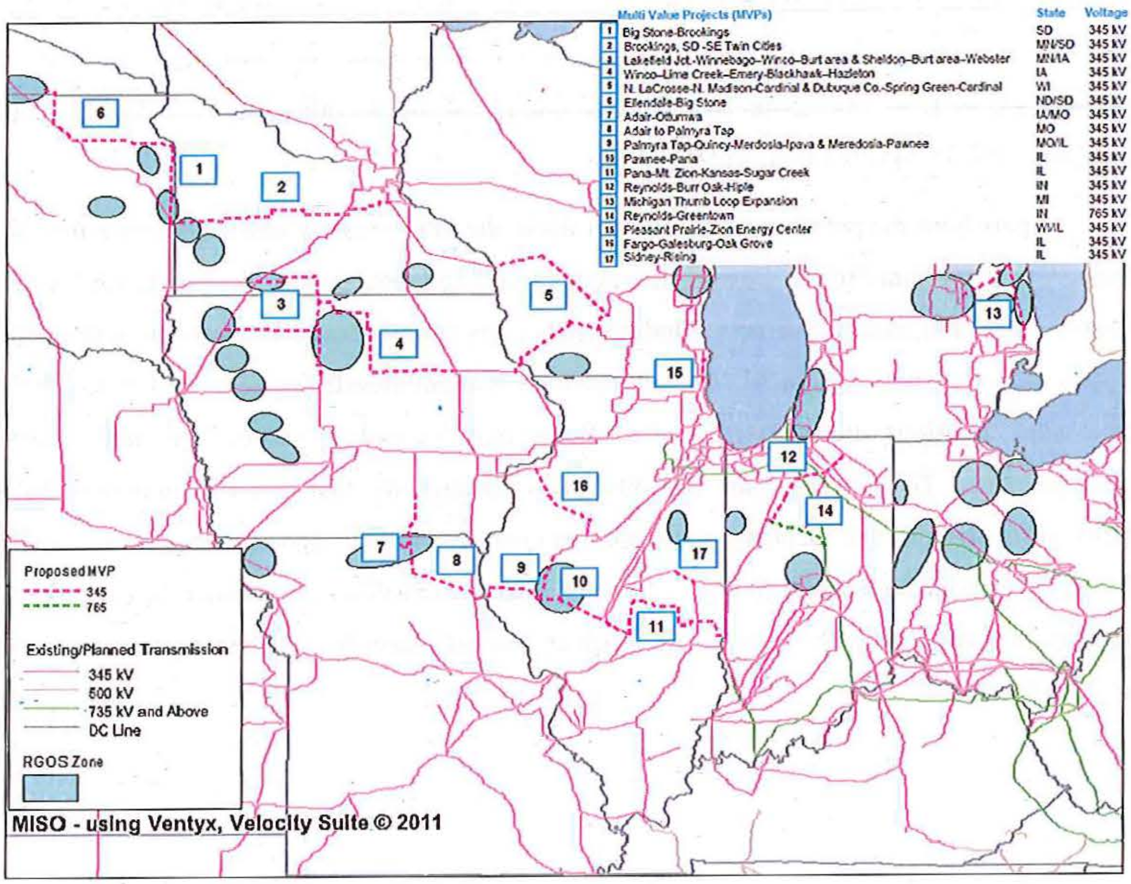

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Table 1

Reduction in New Wind Capacity in the "Without Project" Case

Wind Zone/Farm	State	MW Reduction
Missouri (Zone A)	Missouri	Minimum of: [500, Zone Capacity]
Missouri (Zone C)	Missouri	Minimum of: [356, Zone Capacity]
Iowa (Zone H + I)	Iowa	434.5
Adair	Iowa	174.8
Farmers City	Missouri	146
Rolling Hills	Iowa	250
Walnut Wind	Iowa	150
Total		**1,577.3 – 2,011.3**

Note: Wind zones refer to particular wind farms/projects or generic wind zones developed within MISO's Regional Generation Outlet Study process (November 19, 2010). The particular reductions identified in Table 1 reflect an analysis that identifies the minimum quantity of resources that would need to be reduced to maintain reliable system operations. It does not account for any existing transmission agreements, nor does it reflect any regulatory determination affecting the ability of particular resources to flow power.

Analytical Method

Three sets of computations were performed in order to measure the effect of the Project: (i) a wholesale electric energy price comparison that evaluates changes in Missouri LMPs, (ii) a cost comparison that evaluates changes in production costs needed to meet load in Missouri, and the net change in costs to Missouri from changes in both production costs and construction costs, and (iii) an emissions comparison that evaluates changes in levels of four air emissions. The analytical methods used for these computations are described further below.

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Wholesale Electric Energy Price Comparison

Computation of wholesale electric energy prices is based on two outputs from the PROMOD model: area LMPs and area load. The process used to develop Missouri wholesale energy prices, referred to as Missouri LMPs, is as follows:

1. Hourly area LMPs are calculated by PROMOD and reflect the load-weighted LMP of all nodes within the area.
2. Area load is based on the PROMOD inputs, which were developed by MISO based on hour-by-hour load forecasts from the underlying load-serving entities.[18]
3. The load-weighted average annual LMP is calculated for each area based on the hourly area LMPs and the hourly area loads.[19]
4. The load-weighted LMP for Missouri, or Missouri LMP, is calculated based on each Missouri area's LMP, calculated as described above in #3, weighted by the estimated load for each Missouri area, as described in #2. Some areas, as modeled in PROMOD, include loads in Missouri and one or more neighboring states. In this case, the (1) the load-weighted LMP for the Missouri portion of the area is assumed to be the load-weighted LMP for the entire multi-state area, and (2) the load for the Missouri portion of the area reflects the area's total load (in PROMOD) multiplied by the percent of the area's load that is in Missouri, which is developed using data from the Energy Information Administration.[20]

Cost Comparison

The process used to develop changes in Missouri Production Costs and MISO Production Costs is as follows:

1. Production costs are calculated from PROMOD output for each hour of the year.

[18] These loads reflect forecasts for annual peak load and annual energy shaped over 8,760 hours.

[19] Hours in which the LMP for a Missouri area as calculated by PROMOD is less than -$10/MWh are set to an LMP of -$10/MWh. Hours in which the LMP for a Missouri area is greater than $1,000/MWh are capped at $1,000/MWh.

[20] See Form EIA-861 data files, available at http://www.eia.gov/electricity/data/eia861/index.html, accessed March 2015.

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2. For Missouri Production costs, these costs reflect the hourly fuel, variable operations and maintenance, emission allowance, and start-up costs associated with supplying Missouri load, adjusted for net sales and purchases (imports or exports) of power with areas outside of Missouri, including areas within and outside of MISO. Missouri Production Costs for 2021 and 2016 are calculated as the sum of hourly production costs.
3. For MISO Production costs, these costs reflect the hourly fuel, variable operations and maintenance, emission allowance, and start-up costs associated with supplying MISO load, adjusted for net sales and purchases (imports or exports) of power with areas outside of MISO. MISO Production Costs for 2021 and 2016 are calculated as the sum of hourly production costs.

The process used to develop Missouri Net Costs from the Project is as follows:

1. The present value of total Missouri Production Costs is calculated for the 20-year period, 2019 to 2038, based on the annual Missouri Production Costs for 2021 and 2026. The year 2019 is chosen to start the flow of changes in production costs because this is the first full year in which all elements of the Project are in service.[21] Twenty years of payment reductions are calculated, consistent with the shorter of the two evaluation periods used in MISO's MVP economic analysis.[22] Costs over the period 2019 to 2038 are calculated through interpolation and extrapolation from the 2021 and 2026 results. Annual results are then discounted back to 2014 using both a 3.0 percent and 8.2 percent discount rate to account for a range of possible opportunity costs.[23]
2. The present value of Missouri Net Costs is calculated as the net of (1) total production costs (as calculated in #1) and (2) Missouri customers' portion of Project costs. Missouri customers' portion of Project costs reflects two components. The first is capital costs for new transmission plant. For the purposes of the analysis, costs for new transmission plant are incurred in the year in which associated capital

[21] Testimony of ATXI witness Mr. James Jontry.

[22] MISO evaluates the MVP Portfolio over 20- and 40-year horizons. *See* MVP Report at p 68.

[23] These discount rates are consistent with those used by MISO in its economic analysis. *See* MVP Report at p 68.

expenditures are made. These project costs are based on estimates developed by Ameren.[24] The second component is annual expenses. This cost is based on each company's April 2015 Attachment O rate formula filing.[25] The portion of O&M and Taxes (other than income taxes) allocated to transmission in the formula rate is divided by transmission gross plant in service to calculate an annual transmission expense factor.[26] This factor is then applied to the Project capital cost to estimate ongoing annual expenses for the Project. All future costs are discounted back to 2014. As with all MVPs, transmission costs are then allocated to MISO customers based on their share of MWh load.[27] In the computations herein, MISO Missouri customers are assigned 9.8 percent of the total cost of the Project reflecting the MISO Missouri share of load in 2021, based on the projections in the MISO dataset.[28] Transmission payments for MISO Illinois customers total $38.4 million on a present value basis using a 3 percent discount rate and $30.0 million using an 8.2 percent discount rate.

These net benefits are conservative because they reflect only reduced production costs but do not include other possible reductions in costs such as those associated with potential reductions in capacity, operating reserve and other ancillary service requirements.[29] The estimate also does not account for other benefits to customers, such as improved reliability, the increased ability to meet renewable energy requirements, and emission reductions.

Emissions Comparison

The process used to develop changes in emissions is as follows:

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[24] Direct Testimony of ATXI witness Mr. James Jontry.

[25] Attachment O to MISO Tariff filing, April 2015. Available at https://www.misoenergy.org/_layouts/miso/ecm/redirect.aspx?id=197790, accessed April 2015.

[26] Transmission O&M charges are adjusted to exclude LSE Expenses, Account 565 expenses, FERC Annual Fees, and EPRI & associated expenditures as detailed in Ameren Missouri's Attachment O.

[27] MISO Tariff, Attachment MM, Multi-Value Project Charge.

[28] 9.8 percent is calculated as the MISO Missouri share of total MISO load based on the 2021 Business as Usual: Low Demand scenario.

[29] MVP Report, pp. 50-65.

1. MISO carbon dioxide ("CO_2") emissions are calculated from PROMOD output. The estimated CO_2 quantities in each scenario reflects the sum of emissions from all generation sources within MISO, adjusted for the emissions of net imports and exports between MISO and areas outside of MISO. The emission intensity of imports and exports is assumed to equal the average emission intensity for all generation within MISO.
2. Missouri emissions of nitrogen oxides ("NO_X"), sulfur dioxide ("SO_2") and mercury are calculated from PROMOD output. The reported quantities reflect the sum of emissions from all areas within Missouri. For areas that include portions of both Missouri and one or more neighboring states, Missouri emissions reflect total area emissions multiplied by the percent of each area's load that is in Missouri.

Scenarios

The results presented in the body of this testimony reflect several scenarios, which are detailed below and in Table 2. Each scenario was designed by MISO in its MVP portfolio analysis, and no additional changes have been made. The definitions are provided by MISO in its MVP portfolio analysis report.[30]

- **Business As Usual: Low Demand** – assumes that current energy policies will be continued, with continuing "recession-level" demand and energy growth projections.[31]
- **Business As Usual: High Demand** – assumes that current energy policies will be continued, with demand and energy returning to pre-recession growth rates.[32]
- **Combined Energy Policy** – assumes multiple energy policies are enacted, including a 20 percent federal RPS, a carbon cap modeled on the Waxman-Markey Bill, implementation of a smart grid and widespread adoption of electric vehicles.

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[30] MVP Report, p 52.

[31] Note that the MVP Report titles this case "Business As Usual with Continued Low Demand and Energy Growth (BAULDE)."

[32] Note that the MVP Report titles this case "Business As Usual with Historic Demand and Energy Growth (BAUHDE)."

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- **Carbon Constrained** – assumes that current energy policies will be continued, with the addition of a carbon cap modeled on the Waxman-Markey Bill.

Table 2

Scenario Assumptions[33]

Future Scenarios	Wind Penetration	Effective Demand Growth Rate	Effective Energy Growth Rate	Gas Price	Carbon Cost / Reduction Target
Business As Usual: Low Demand	State RPS	0.78 percent	0.79 percent	BAU	None
Business As Usual: High Demand	State RPS	1.28 percent	1.42 percent	BAU	None
Combined Energy Policy	20 percent Federal RPS by 2025	0.52 percent	0.68 percent	BAU + $3	$50/ton (42 percent by 2033)
Carbon Constrained	State RPS	0.03 percent	0.05 percent	BAU + $3	$50/ton (42 percent by 2033)

[33] Table 2 is based on Table 8.1 from the MVP Report.

Table 1
Change in Missouri LMP Due to the Mark Twain Project

Scenario	Year	Missouri LMP ($ per MWh) With Project [A]	Without Project [B]	Difference [C] = [A] - [B]	Percent Difference [D] = [C]/[B]
Business as Usual: Low Demand	2021	$35.34	$35.69	-$0.35	-0.98%
	2026	$40.72	$40.90	-$0.17	-0.42%
Business as Usual: High Demand	2021	$41.58	$42.06	-$0.48	-1.14%
	2026	$51.45	$52.00	-$0.55	-1.05%
Combined Energy Policy	2021	$88.11	$89.19	-$1.08	-1.21%
	2026	$104.29	$105.32	-$1.03	-0.97%
Carbon Constrained	2021	$82.54	$83.02	-$0.49	-0.58%
	2026	$93.96	$94.30	-$0.35	-0.37%

Notes:
[1] Load weighted values reflect all Missouri loads, including the Missouri portions of companies that span multiple states, as determined by the proportion of retail sales in Missouri.
[2] A negative value in column [C] indicates a reduction in LMP due to the Project.

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Table 2
Change in Missouri Production Cost Due to the Mark Twain Project

Scenario	Year	Missouri Production Cost ($ millions) With Project	Without Project	Difference	Percent Difference
		[A]	[B]	[C] = [A] - [B]	[D] = [C]/[B]
Business as Usual: Low Demand	2021	$2,658.8	$2,755.9	-$97.0	-3.52%
	2026	$3,236.0	$3,340.7	-$104.7	-3.13%
Business as Usual: High Demand	2021	$3,121.4	$3,236.0	-$114.6	-3.54%
	2026	$4,194.2	$4,341.4	-$147.2	-3.39%
Combined Energy Policy	2021	$6,862.9	$7,092.5	-$229.6	-3.24%
	2026	$8,337.9	$8,629.9	-$292.0	-3.38%
Carbon Constrained	2021	$6,275.7	$6,502.8	-$227.1	-3.49%
	2026	$6,970.4	$7,221.3	-$250.9	-3.47%

Notes:
[1] Values reflect all production costs in Missouri, including the Missouri portions of companies that span multiple states, as determined by the proportion of retail sales in Missouri.
[2] A negative value in column [C] indicates a reduction in production cost due to the Project.

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Table 3
Change in MISO Production Cost Due to the Mark Twain Project

Scenario	Year	MISO Production Cost ($ millions)			Percent
		With Project	Without Project	Difference	Difference
		[A]	[B]	[C] = [A] - [B]	[D] = [C]/[B]
Business as Usual: Low Demand	2021	$13,219.5	$13,420.5	-$201.0	-1.50%
	2026	$15,475.0	$15,703.5	-$228.5	-1.46%
Business as Usual: High Demand	2021	$15,817.4	$16,055.7	-$238.2	-1.48%
	2026	$20,313.4	$20,605.1	-$291.7	-1.42%
Combined Energy Policy	2021	$30,437.6	$30,908.7	-$471.1	-1.52%
	2026	$35,919.3	$36,419.0	-$499.8	-1.37%
Carbon Constrained	2021	$26,756.3	$27,221.5	-$465.2	-1.71%
	2026	$28,967.2	$29,469.1	-$501.9	-1.70%

Note:
[1] A negative value in column [C] indicates a reduction in production cost due to the Project.

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Table 4
Missouri Net Cost Impact Due to the Mark Twain Project, NPV as of 2014

	Discount Rate 3%				Discount Rate 8.2%			
	Difference in Production Cost (PV, $ millions)	MISO MO Share of Project Costs (PV, $ millions)	Difference in Net Costs ($ millions)	Ratio	Difference in Production Cost (PV, $ millions)	MISO MO Share of Project Costs (PV, $ millions)	Difference in Net Costs ($ millions)	Ratio
	[A]	[B]	[C]=[A]+[B]	[D]=-[A]/[B]	[E]	[F]	[G]=[E]+[F]	[H]=-[E]/[F]
Business as Usual: Low Demand	-$1,414.3	$38.4	-$1,375.9	36.8	-$738.6	$30.0	-$708.6	24.6
Business as Usual: High Demand	-$2,076.9	$38.4	-$2,038.5	54.1	-$1,038.1	$30.0	-$1,008.1	34.6
Combined Energy Policy	-$4,110.4	$38.4	-$4,072.0	107.1	-$2,059.1	$30.0	-$2,029.1	68.6
Carbon Constrained	-$3,412.2	$38.4	-$3,373.9	88.9	-$1,770.2	$30.0	-$1,740.2	59.0

Notes:
[1] Values reflect all production costs in Missouri, including the Missouri portions of companies that span multiple states, as determined by the proportion of retail sales in Missouri.
[2] All values are shown on an NPV basis over the time period 2014-2038.
[3] A negative value in columns [A] or [E] indicates a reduction in production cost due to the Project. Difference in Adjusted Production Cost is calculated in detail in Exhibit X.7.
[4] MISO Missouri Share of Project Costs is the Missouri share of total MISO Load (9.8%) multiplied by the total PV of project costs, equal to $391m and $305m for discount rates of 3% and 8.2%, respectively.

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Table 5 (Page 1)
Change in Missouri Production Cost Due to the Mark Twain Project
Business as Usual: Low Demand Scenario

	Production Cost						Difference in Missouri Production Cost (\$ millions, PV as of 2014)	
Year	With Project (\$ millions)	Without Project (\$ millions)	Difference (\$ millions)	Percent Difference	PV Factor (3%)	PV Factor (8.2%)	PV (3%)	PV (8.2%)
	[A]	[B]	[C]=[A]-[B]	[D]=[C]/[A]	[E]	[F]	[G]=[C]*[E]	[H]=[C]*[F]
2019	\$2,427.9	\$2,521.9	-\$94.0	-3.9%	0.863	0.674	-\$81.1	-\$63.4
2020	\$2,543.4	\$2,638.9	-\$95.5	-3.8%	0.837	0.623	-\$80.0	-\$59.5
2021	\$2,658.8	\$2,755.9	-\$97.0	-3.6%	0.813	0.576	-\$78.9	-\$55.9
2022	\$2,774.3	\$2,872.8	-\$98.6	-3.6%	0.789	0.532	-\$77.8	-\$52.5
2023	\$2,889.7	\$2,989.8	-\$100.1	-3.5%	0.766	0.492	-\$76.7	-\$49.2
2024	\$3,005.1	\$3,106.7	-\$101.6	-3.4%	0.744	0.455	-\$75.6	-\$46.2
2025	\$3,120.6	\$3,223.7	-\$103.1	-3.3%	0.722	0.420	-\$74.5	-\$43.3
2026	\$3,236.0	\$3,340.7	-\$104.7	-3.2%	0.701	0.388	-\$73.4	-\$40.7
2027	\$3,351.4	\$3,457.6	-\$106.2	-3.2%	0.681	0.359	-\$72.3	-\$38.1
2028	\$3,466.9	\$3,574.6	-\$107.7	-3.1%	0.661	0.332	-\$71.2	-\$35.7
2029	\$3,582.3	\$3,691.6	-\$109.3	-3.0%	0.642	0.307	-\$70.1	-\$33.5
2030	\$3,697.8	\$3,808.5	-\$110.8	-3.0%	0.623	0.283	-\$69.0	-\$31.4
2031	\$3,813.2	\$3,925.5	-\$112.3	-2.9%	0.605	0.262	-\$67.9	-\$29.4
2032	\$3,928.6	\$4,042.5	-\$113.8	-2.9%	0.587	0.242	-\$66.9	-\$27.6
2033	\$4,044.1	\$4,159.4	-\$115.4	-2.9%	0.570	0.224	-\$65.8	-\$25.8
2034	\$4,159.5	\$4,276.4	-\$116.9	-2.8%	0.554	0.207	-\$64.7	-\$24.2
2035	\$4,274.9	\$4,393.4	-\$118.4	-2.8%	0.538	0.191	-\$63.7	-\$22.6
2036	\$4,390.4	\$4,510.3	-\$119.9	-2.7%	0.522	0.177	-\$62.6	-\$21.2
2037	\$4,505.8	\$4,627.3	-\$121.5	-2.7%	0.507	0.163	-\$61.5	-\$19.8
2038	\$4,621.2	\$4,744.2	-\$123.0	-2.7%	0.492	0.151	-\$60.5	-\$18.6
				Present Value of Missouri Production Cost (\$ millions, PV as of 2014):			-\$1,414.3	-\$738.6

Notes:

[1] Values reflect all production costs in Missouri, including the Missouri portions of companies that span multiple states, as determined by the proportion of retail sales in Missouri.

[2] A negative value in column [C] indicates a reduction in production cost due to the Project.

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Table 5 (Page 2)
Change in Missouri Production Cost Due to the Mark Twain Project
Business as Usual: High Demand Scenario

	Production Cost						Difference in Missouri Production Cost ($ millions, PV as of 2014)	
Year	With Project ($ millions)	Without Project ($ millions)	Difference ($ millions)	Percent Difference	PV Factor (3%)	PV Factor (8.2%)	PV (3%)	PV (8.2%)
	[A]	[B]	[C]=[A]-[B]	[D]=[C]/[A]	[E]	[F]	[G]=[C]*[E]	[H]=[C]*[F]
2019	$2,692 3	$2,793.9	-$101.6	-3.8%	0.863	0.674	-$87.7	-$68.5
2020	$2,906.8	$3,014.9	-$108.1	-3.7%	0.837	0.623	-$90.6	-$67.4
2021	$3,121.4	$3,236.0	-$114.6	-3.7%	0.813	0.576	-$93.2	-$66.0
2022	$3,335.9	$3,457.1	-$121.2	-3.6%	0.789	0.532	-$95.6	-$64.5
2023	$3,550.5	$3,678.2	-$127.7	-3.6%	0.766	0.492	-$97.8	-$62.8
2024	$3,765.1	$3,899.2	-$134.2	-3.6%	0.744	0.455	-$99.8	-$61.0
2025	$3,979.6	$4,120.3	-$140.7	-3.5%	0.722	0.420	-$101.6	-$59.1
2026	$4,194.2	$4,341.4	-$147.2	-3.5%	0.701	0.388	-$103.2	-$57.2
2027	$4,408.7	$4,562.5	-$153.7	-3.5%	0.681	0.359	-$104.7	-$55.2
2028	$4,623.3	$4,783.5	-$160.2	-3.5%	0.661	0.332	-$105.9	-$53.2
2029	$4,837.9	$5,004.6	-$166.7	-3.4%	0.642	0.307	-$107.0	-$51.1
2030	$5,052.4	$5,225.7	-$173.3	-3.4%	0.623	0.283	-$108.0	-$49.1
2031	$5,267.0	$5,446.8	-$179.8	-3.4%	0.605	0.262	-$108.8	-$47.1
2032	$5,481.6	$5,667.8	-$186.3	-3.4%	0.587	0.242	-$109.4	-$45.1
2033	$5,696.1	$5,888.9	-$192.8	-3.4%	0.570	0.224	-$109.9	-$43.1
2034	$5,910.7	$6,110.0	-$199.3	-3.4%	0.554	0.207	-$110.4	-$41.2
2035	$6,125.2	$6,331.1	-$205.8	-3.4%	0.538	0.191	-$110.6	-$39.3
2036	$6,339.8	$6,552.1	-$212.3	-3.3%	0.522	0.177	-$110.8	-$37.5
2037	$6,554.4	$6,773.2	-$218.8	-3.3%	0.507	0.163	-$110.9	-$35.7
2038	$6,768.9	$6,994.3	-$225.4	-3.3%	0.492	0.151	-$110.9	-$34.0
				Present Value of Missouri Production Cost ($ millions, PV as of 2014):			-$2,076.9	-$1,038.1

Notes:

[1] Values reflect all production costs in Missouri, including the Missouri portions of companies that span multiple states, as determined by the proportion of retail sales in Missouri.

[2] A negative value in column [C] indicates a reduction in production cost due to the Project.

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Table 5 (Page 3)
Change in Missouri Production Cost Due to the Mark Twain Project
Combined Energy Policy Scenario

	Production Cost						Difference in Missouri Production Cost (S millions, PV as of 2014)	
Year	With Project (S millions)	Without Project (S millions)	Difference (S millions)	Percent Difference	PV Factor (3%)	PV Factor (8.2%)	PV (3%)	PV (8.2%)
	[A]	[B]	[C]=[A]-[B]	[D]=[C]/[A]	[E]	[F]	[G]=[C]*[E]	[H]=[C]*[F]
2019	$6,272.9	$6,477.6	-$204.6	-3.3%	0.863	0.674	-$176.5	-$138.0
2020	$6,567.9	$6,785.0	-$217.1	-3.3%	0.837	0.623	-$181.8	-$135.3
2021	$6,862.9	$7,092.5	-$229.6	-3.3%	0.813	0.576	-$186.7	-$132.2
2022	$7,157.9	$7,400.0	-$242.1	-3.4%	0.789	0.532	-$191.1	-$128.9
2023	$7,452.9	$7,707.5	-$254.5	-3.4%	0.766	0.492	-$195.1	-$125.2
2024	$7,747.9	$8,014.9	-$267.0	-3.4%	0.744	0.455	-$198.7	-$121.4
2025	$8,042.9	$8,322.4	-$279.5	-3.5%	0.722	0.420	-$201.9	-$117.5
2026	$8,337.9	$8,629.9	-$292.0	-3.5%	0.701	0.388	-$204.8	-$113.4
2027	$8,632.9	$8,937.4	-$304.4	-3.5%	0.681	0.359	-$207.3	-$109.3
2028	$8,927.9	$9,244.8	-$316.9	-3.5%	0.661	0.332	-$209.5	-$105.1
2029	$9,222.9	$9,552.3	-$329.4	-3.6%	0.642	0.307	-$211.4	-$101.0
2030	$9,517.9	$9,859.8	-$341.9	-3.6%	0.623	0.283	-$213.0	-$96.9
2031	$9,812.9	$10,167.3	-$354.3	-3.6%	0.605	0.262	-$214.4	-$92.8
2032	$10,107.9	$10,474.7	-$366.8	-3.6%	0.587	0.242	-$215.5	-$88.8
2033	$10,402.9	$10,782.2	-$379.3	-3.6%	0.570	0.224	-$216.3	-$84.9
2034	$10,697.9	$11,089.7	-$391.8	-3.7%	0.554	0.207	-$216.9	-$81.0
2035	$10,992.9	$11,397.2	-$404.2	-3.7%	0.538	0.191	-$217.3	-$77.2
2036	$11,287.9	$11,704.6	-$416.7	-3.7%	0.522	0.177	-$217.5	-$73.6
2037	$11,582.9	$12,012.1	-$429.2	-3.7%	0.507	0.163	-$217.5	-$70.1
2038	$11,877.9	$12,319.6	-$441.7	-3.7%	0.492	0.151	-$217.3	-$66.6
				Present Value of Missouri Production Cost (S millions, PV as of 2014):			-$4,110.4	-$2,059.1

Notes:

[1] Values reflect all production costs in Missouri, including the Missouri portions of companies that span multiple states, as determined by the proportion of retail sales in Missouri.

[2] A negative value in column [C] indicates a reduction in production cost due to the Project.

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Table 5 (Page 4)
Change in Missouri Production Cost Due to the Mark Twain Project
Carbon Constrained Scenario

	Production Cost						Difference in Missouri Production Cost ($ millions, PV as of 2014)	
Year	With Project ($ millions)	Without Project ($ millions)	Difference ($ millions)	Percent Difference	PV Factor (3%)	PV Factor (8.2%)	PV (3%)	PV (8.2%)
	[A]	[B]	[C]=[A]-[B]	[D]=[C]/[A]	[E]	[F]	[G]=[C]*[E]	[H]=[C]*[F]
2019	$5,997.8	$6,215.4	-$217.6	-3.6%	0.863	0.674	-$187.7	-$146.7
2020	$6,136.8	$6,359.1	-$222.3	-3.6%	0.837	0.623	-$186.2	-$138.6
2021	$6,275.7	$6,502.8	-$227.1	-3.6%	0.813	0.576	-$184.7	-$130.8
2022	$6,414.6	$6,646.5	-$231.9	-3.6%	0.789	0.532	-$183.0	-$123.4
2023	$6,553.6	$6,790.2	-$236.6	-3.6%	0.766	0.492	-$181.3	-$116.4
2024	$6,692.5	$6,933.9	-$241.4	-3.6%	0.744	0.455	-$179.6	-$109.8
2025	$6,831.4	$7,077.6	-$246.1	-3.6%	0.722	0.420	-$177.8	-$103.4
2026	$6,970.4	$7,221.3	-$250.9	-3.6%	0.701	0.388	-$176.0	-$97.4
2027	$7,109.3	$7,365.0	-$255.7	-3.6%	0.681	0.359	-$174.1	-$91.8
2028	$7,248.3	$7,508.7	-$260.4	-3.6%	0.661	0.332	-$172.2	-$86.4
2029	$7,387.2	$7,652.4	-$265.2	-3.6%	0.642	0.307	-$170.2	-$81.3
2030	$7,526.1	$7,796.1	-$269.9	-3.6%	0.623	0.283	-$168.2	-$76.5
2031	$7,665.1	$7,939.8	-$274.7	-3.6%	0.605	0.262	-$166.2	-$71.9
2032	$7,804.0	$8,083.5	-$279.5	-3.6%	0.587	0.242	-$164.1	-$67.6
2033	$7,942.9	$8,227.2	-$284.2	-3.6%	0.570	0.224	-$162.1	-$63.6
2034	$8,081.9	$8,370.8	-$289.0	-3.6%	0.554	0.207	-$160.0	-$59.7
2035	$8,220.8	$8,514.5	-$293.7	-3.6%	0.538	0.191	-$157.9	-$56.1
2036	$8,359.8	$8,658.2	-$298.5	-3.6%	0.522	0.177	-$155.8	-$52.7
2037	$8,498.7	$8,801.9	-$303.2	-3.6%	0.507	0.163	-$153.7	-$49.5
2038	$8,637.6	$8,945.6	-$308.0	-3.6%	0.492	0.151	-$151.5	-$46.5
				Present Value of Missouri Production Cost ($ millions, PV as of 2014):			-$3,412.2	-$1,770.2

Notes:

[1] Values reflect all production costs in Missouri, including the Missouri portions of companies that span multiple states, as determined by the proportion of retail sales in Missouri.

[2] A negative value in column [C] indicates a reduction in production cost due to the Project.

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Table 6
Change in MISO CO_2 Emissions Due to the Mark Twain Project

Scenario	Year	MISO CO_2 Emissions (tons) With Project [A]	Without Project [B]	Difference [C] = [A] - [B]	Percent Difference [D] = [C]/[B]
Business as Usual: Low Demand	2021	353,796,235	358,214,454	-4,418,219	-1.23%
	2026	361,460,129	365,625,544	-4,165,415	-1.14%
Business as Usual: High Demand	2021	382,241,299	386,647,764	-4,406,465	-1.14%
	2026	405,571,471	409,559,106	-3,987,635	-0.97%
Combined Energy Policy	2021	319,579,416	323,271,258	-3,691,843	-1.14%
	2026	278,255,301	280,801,256	-2,545,955	-0.91%
Carbon Constrained	2021	298,871,406	302,956,858	-4,085,452	-1.35%
	2026	270,296,185	273,453,948	-3,157,763	-1.15%

Notes:
[1] Emission values are adjusted for net imports into the region.
[2] A negative value in column [C] indicates a reduction in CO_2 emissions due to the Project.

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Table 7
Change in Missouri NO_x Emissions Due to the Mark Twain Project

Scenario	Year	Missouri NO_x Emissions (lbs) With Project	Without Project	Difference	Percent Difference
		[A]	[B]	[C] = [A] - [B]	[D] = [C]/[B]
Business as Usual: Low Demand	2021	114,707,519	115,969,405	-1,261,887	-1.09%
	2026	111,045,266	112,389,869	-1,344,603	-1.20%
Business as Usual: High Demand	2021	124,187,632	125,451,448	-1,263,816	-1.01%
	2026	126,112,654	127,179,726	-1,067,071	-0.84%
Combined Energy Policy	2021	79,587,292	80,616,551	-1,029,259	-1.28%
	2026	47,449,907	47,987,890	-537,983	-1.12%
Carbon Constrained	2021	85,355,070	86,392,206	-1,037,136	-1.20%
	2026	53,199,360	53,800,488	-601,128	-1.12%

Notes:

[1] Values reflect all emissions in Missouri, including the Missouri portions of companies that span multiple states, as determined by the proportion of retail sales in Missouri.

[2] A negative value in column [C] indicates a reduction in NO_x emissions due to the Project.

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Table 8
Change in Missouri SO_2 Emissions Due to the Mark Twain Project

Scenario	Year	Missouri SO_2 Emissions (lbs)			Percent Difference
		With Project	Without Project	Difference	
		[A]	[B]	[C] = [A] - [B]	[D] = [C]/[B]
Business as Usual: Low Demand	2021	467,456,587	471,602,922	-4,146,335	-0.88%
	2026	455,500,178	459,592,491	-4,092,313	-0.89%
Business as Usual: High Demand	2021	508,145,146	512,406,075	-4,260,928	-0.83%
	2026	517,539,943	520,133,833	-2,593,891	-0.50%
Combined Energy Policy	2021	316,292,582	320,073,185	-3,780,603	-1.18%
	2026	240,900,823	242,683,100	-1,782,277	-0.73%
Carbon Constrained	2021	338,994,649	342,098,129	-3,103,480	-0.91%
	2026	269,264,479	270,730,200	-1,465,721	-0.54%

Notes:
[1] Values reflect all emissions in Missouri, including the Missouri portions of companies that span multiple states, as determined by the proportion of retail sales in Missouri.
[2] A negative value in column [C] indicates a reduction in SO_2 emissions due to the Project.

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Table 9
Change in Missouri Mercury Emissions Due to the Mark Twain Project

Scenario	Year	Missouri Mercury Emissions (lbs) With Project [A]	Without Project [B]	Difference [C] = [A] - [B]	Percent Difference [D] = [C]/[B]
Business as Usual: Low Demand	2021	2,934	2,958	-24	-0.81%
	2026	2,846	2,875	-29	-1.00%
Business as Usual: High Demand	2021	3,076	3,097	-21	-0.68%
	2026	3,093	3,112	-19	-0.62%
Combined Energy Policy	2021	2,123	2,148	-24	-1.14%
	2026	1,641	1,655	-14	-0.86%
Carbon Constrained	2021	2,372	2,398	-26	-1.08%
	2026	1,779	1,797	-17	-0.97%

Notes:
[1] Values reflect all emissions in Missouri, including the Missouri portions of companies that span multiple states, as determined by the proportion of retail sales in Missouri.
[2] A negative value in column [C] indicates a reduction in mercury emissions due to the Project.

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